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STUDIES IN TACTICAL SYMBOLOGY. I. PREFERRED TACTICAL SYMBOLOGY --ETC(U)

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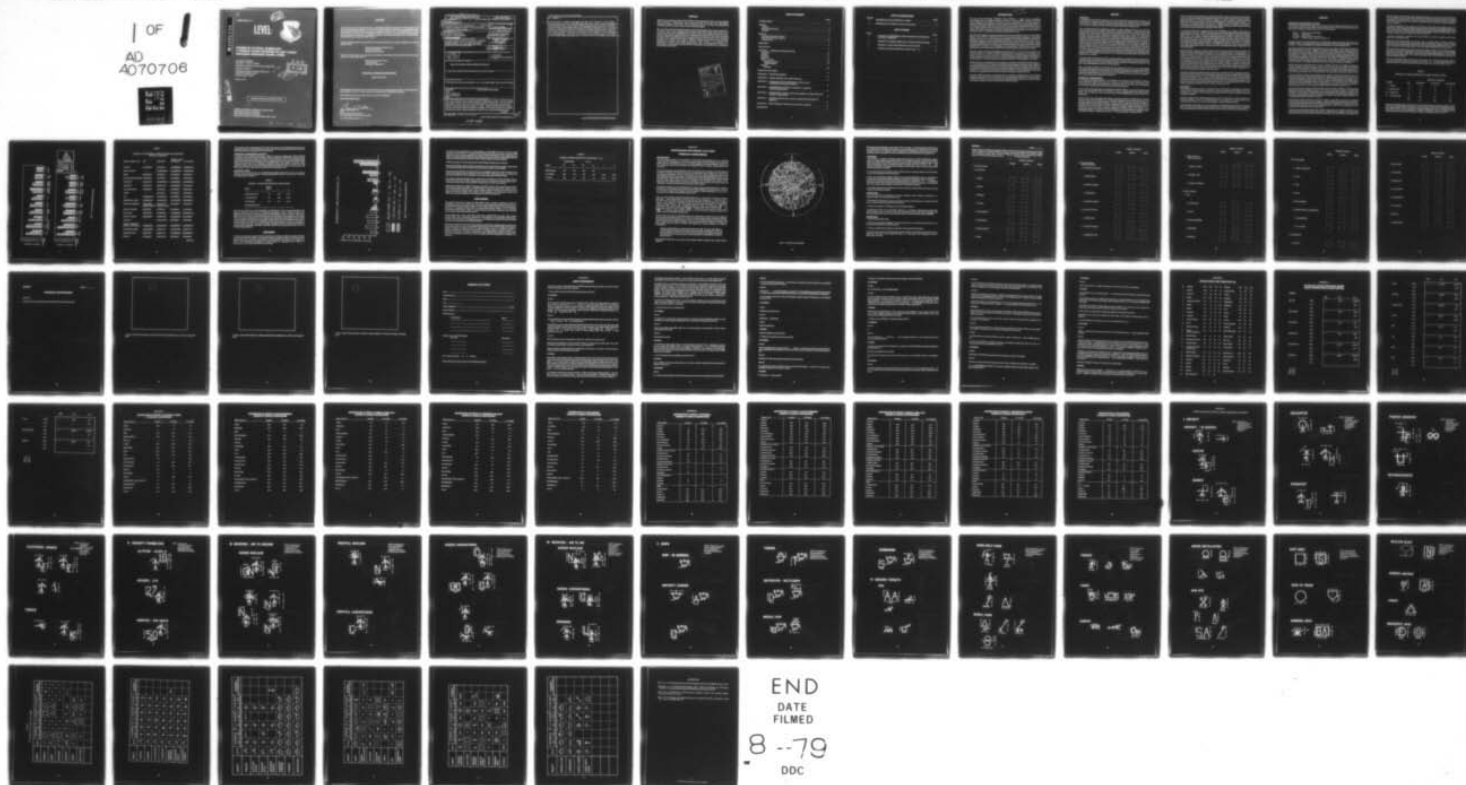
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STUDIES IN TACTICAL SYMBOLOGY
I. Preferred Tactical SymboLOGY for Joint Tactical
Information Distribution System (JTIDS)

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February 1979



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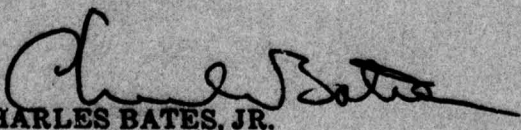
TECHNICAL REVIEW AND APPROVAL

AMRL-TR-78-115

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

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FOR THE COMMANDER



CHARLES BATES, JR.

Chief

Human Engineering Division
Aerospace Medical Research Laboratory

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes one of a series of studies attempting to design an optimal symbol set to use in tactical order-of-battle display for single seat aircraft. Air Force tactical pilots flying F-111D's and F-15's were interviewed to ascertain their preferences for symbols to represent 42 tactical objects or events. Modal or typical symbol constructions for each object/event for both types of pilots were selected, tabled, and compared with choices of naive college students and a panel of Air Force professional human (Cont'd)		

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20. Abstract

→ factors personnel. Pilots scored significantly higher than students on a set of spatial perception tests, were more consistent among themselves in type of symbol constructed, and remembered their symbols better; these stereotypical pilot responses presumably reflect the effect of their flight training and experience. → Conclusions were: (1) symbols should be as realistic or pictorial as possible, (2) existing standard symbols should be used, and (3) the symbol set should be standardized at the highest Air Force administrative level practicable. Pilot-in-the-loop mission based simulations are to be developed in which tactical display symbology will be evaluated based on the findings of this study. ←

PREFACE

This report was prepared by the Systems Research Branch, Human Engineering Division, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio 45433, under Project 7184, "Man-Machine Integration Technology," Task 718414, "Operator Workload Assessment." Mr. Billy M. Crawford was the Task Scientist and Mr. William H. Pearson was the Principal Investigator.

Data were collected from F-111D pilots belonging to the 27th Tactical Flight Wing at Cannon AFB, Clovis, New Mexico, and F-15 pilots belonging to the 1st Tactical Fighter Wing, Langley AFB, Newport News, Virginia. The authors wish to thank Headquarters Tactical Air Command for granting permission to interview these pilots and especially to thank these men for contributing their knowledge and time so freely and making this study possible. Any usefulness this report may possess is because of their experience, opinions, and tactical knowledge. These symbols have been given a preliminary inspection by the members of the Symbology Standardization Committee (SSC) created by Electronic Systems Division, L. G. Hanscom AFB, Massachusetts, to propose a list of JTIDS symbols. In many cases an exactly appropriate symbol for the tactical object or event had not been created by the SSC and the authors accept full blame for not reflecting the spirit and intentions of the SSC.

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INTRODUCTION

The Joint Tactical Information Distribution System (JTIDS) is a digital, secure, jam-resistant, communication system for real-time command and control of combat operations. The system uses Time Division Multiple Access (TDMA) to interconnect all system participants into one common channel, or network, for distribution of information. A major component in the system is the electronic display device or CRT terminal with which the pilot in an aircraft will receive and transmit tactical information such as aircraft present position, position of other aircraft, ground/air targets and threats, weather, and so on. In order to optimize the transfer of information and retain a sufficient quantity of information on a small CRT, it is necessary to devise a set of symbols to represent the tactical entities of concern.

Essential JTIDS information requirements for fighter aircraft were provided by the Air Force Tactical Fighter Weapons Center (TFWC) in September 1975. Aeronautical Systems Division, Deputy for Aeronautical Equipment, Directorate of Avionics Standardization and Systems Architecture (ASD/AES) and Deputy for Engineering, Directorate of Avionics Engineering (ASD/ENA), used the TFWC study to derive a set of information requirements which are common across the major tactical missions. Results of preliminary studies indicated that additional work on symbology to represent the information requirements was necessary and that standardization of symbology was an immediate need. Standardization would avoid the current symbol proliferation trend by which contractors introduce their preferred symbol set with each contract aircraft.

ASD/AES formed a Symbology Standardization Committee (SSC) in April 1976 with members from ASD/AES, ASD/ENA, ASD/ENE, AFFDL, AMRL, and AFAL. The purpose of the committee was to produce a symbol set to be used in conjunction with a JTIDS display. This Phase I effort was completed in six months and because of the short time span, no experimental research could be conducted to determine an optimal symbol set. The details of this effort are contained in ASD TR-77-31 (Churchwell, J., et al., 1977).

The SSC derived a set of symbols based on the information requirements mentioned above and also based on the recommendations of some 33 Government and industry research agencies surveyed in the study. Follow-on recommendations suggested by the SSC at the end of this first phase included: investigation of the confusion of symbols both within a symbol set and between symbol sets; population stereotypes of symbol construction; and investigation of the interpretation and dynamics of the SSC symbol set. These recommendations, along with three more, were suggested in order to address the problem of obtaining an optimal symbol set.

The purpose of this report, then, is to present the results of a preliminary investigation into the area of JTIDS symbol set optimization. All three of the SSC follow-on recommendations mentioned above are being pursued by AMRL at this time; however, the following report addresses primarily population stereotypes of symbol construction and subjective comments on interpretation of the SSC symbols.

METHOD

APPROACH

One straightforward method for finding the most readily interpretable symbols should be simply to ask potential users for their preferences and select the modal responses for each symbol. This was the approach used in this survey. Subjects were given specific information requirements and asked to construct symbols for each requirement. Population stereotypes were also considered in the study as indicated below:

Data were obtained from three populations of subjects: 53 college engineering students, 39 F-111D TAC pilots, and 22 F-15 TAC pilots. Selection rationale for the samples was as follows: It was thought that college students would represent a group which was relatively uncontaminated by Air Force training, experience, and familiarity with tactical mission information requirements such as map, weather, and order-of-battle symbology. These naive subjects would not have knowledge of existing symbology and thus would neither be influenced nor inhibited in their construction of symbols. The F-111D pilots represented a group who use an operational CRT for information display. They are familiar with electronically displayed symbology as depicted on the Vertical Situation Display and the Moving Map Display. These devices do not approach the complex symbology problem associated with the proposed JTIDS; however, the investigators thought that it would be desirable to query a group that at least had an appreciation for the operational use of electronic symbology. The F-111D pilots also represented a group whose primary mission is air-to-ground oriented. The F-15 pilots represented a group whose decisions and activities are centered around the single-seat aircraft concept. It was believed desirable to obtain symbol concepts from those who will be tasked with flying a highly complex aircraft with JTIDS and doing it alone. The F-15 pilots also represented a group whose mission was primarily air-to-air oriented.

Two types of data were collected from all three sample populations: (1) symbol formats for specific types of tactical information and (2) individual spatial perception scores. In addition, data were collected from the pilot populations on general attitudes toward the JTIDS concept and cockpit control/display instrumentation, and also on educational background and Air Force flying experience.

Data were collected manually. The instrument used for symbol format data was a two part symbology questionnaire developed in-house by the investigators. Spatial perception scores were obtained using a portion of the Differential Aptitude Test (DAT) (Buros, 1941) and the Rotated Blocks Test (Hunter, 1975). Group discussions were held with pilots to obtain comments on the JTIDS concept, and they were also requested to fill in a personal data sheet on background and experience.

SYMBOLGY QUESTIONNAIRE

The symbology questionnaire (Appendix 1) was designed to survey ideas for specific symbols to represent tactical information requirements such as those proposed for the JTIDS system. The purpose of the questionnaire was twofold: (1) to gain insight as to the preferred design of each symbol and (2) to determine how well a subject remembered the meaning of the symbol he had constructed.

The two sections of the questionnaire were administered separately. Subjects were not aware that the second section of the questionnaire would test their ability to recall the symbols constructed in the first section. Subjects were not allowed to refer to the first section while accomplishing the second section of the questionnaire.

The first section of the questionnaire asked subjects to construct symbols for 45 different items of tactical information. These items were different but not necessarily independent. The order in which the items were presented suggested a building-block approach. A generic symbol was asked for followed by requests for subcategories of that generic symbol. For example: the subjects were asked to construct a symbol for Aircraft (in general). They were then asked to construct symbols for Interceptor, Bomber, Helicopter, and so on. Further down in the list of items, symbols were requested for armament carried on an aircraft. It was presumed that subjects would construct a relatively independent generic symbol and then modify that symbol with additional markings — alphanumerics, and so on — to form the dependent subcategory symbol.

In the second section of the questionnaire, the subjects were asked to recall several of their Section I responses in order to combine independent and dependent symbols into five complex symbols having several levels of integrated information. For example, in Section I, subjects were asked to construct symbols for Friendly, Enemy, and Unknown Aircraft, and symbols for the flight parameters — Heading, Airspeed, Altitude — and symbols for the armament carried on the aircraft — Missiles, Guided or Unguided, and Nuclear or Conventional. In Section II the subject was asked to draw a symbol representing an enemy interceptor heading north at high airspeed and altitude carrying guided nuclear missiles.

Two paper and pencil tests of spatial perception were administered to the subjects. These tests were recommended by D. Hunter of AFHRL, Personnel Selection and Screening Branch, Personnel Laboratory, Lackland AFB, Texas. These were the Space Relations Test from the Differential Aptitude Test (DAT) (Buros, 1941), a test of pattern recognition (Mental Measurements Yearbook, p. 1046); and the Rotated Blocks Test (Hunter, 1975), a test for assessing three dimensional visual perception. These tests were given so as to establish a quantitative index of the subjects' ability to visualize complex relationships and to maintain those relationships while reconstructing figures or integrating the figures into a new context. It was believed that the logic and thought processes required to accomplish these tasks are similar to those required for constructing 2-dimensional symbols to represent real-world, multi-dimensional entities integrating various levels of information.

After the symbology questionnaire had been completed, the TAC pilots participated in group discussions. The JTIDS concept was presented by the investigator as was the unclassified portion of the SSC symbol set. No attempt was made to "sell" JTIDS or the symbol set. The symbols and their use of JTIDS display were explained in an objective manner. A common set of questions was asked (see Appendix 2) during each of the group sessions and the discussions were tape-recorded. The responses to questions published here are verbatim in many instances; however, some comments were added to clarify the context of the responses and in some cases simultaneous responses were consolidated into one statement. Subjects were asked to compare their constructed symbols with the SSC symbol set and also to give their opinion on whether they felt the SSC symbols would overload them with information. They were also asked questions about their preferences for cockpit controls with which to interact with JTIDS and how they felt about the display configurations, i.e. CRT, HUD, Helmet Mounted Display, audio tones, and etc.

Educational background and flying experience of pilots were considered as having a potential relationship to the other types of data collected. A pilot with a degree in engineering, for instance, might be able to analyze the drawings in the perception tests in a more systematic fashion than would a pilot with a degree in political science. Flying experience which was primarily air-to-ground might influence construction of symbols related to that mission. The data were collected but are not included in the results. There has been no attempt as yet to analyze the other data in light of personal data factors, except in a very general sense because F-111 pilots perform a primarily air-to-ground role and F-15 pilots are primarily air-to-air.

PROCEDURE

The symbology questionnaire, Section I, was administered to the subjects followed immediately by Section II. No time limit was set for the completion of either part — subjects were allowed to work at their own pace. The investigators were available to answer questions and clarify terms but they did not contribute to the actual construction of symbols.

Following completion of the symbology questionnaire, the DAT was administered. Twenty-five minutes were allowed for completion of this test. The Rotated Blocks Test was then given and no time limit was set. Completion time was, however, noted and was considered as a potential dependent variable.

Group discussions with the pilots were not held until after the symbology questionnaire had been completed. This was to ensure that the subjects would not be influenced by a preview of the SSC symbol set. Personal data sheets were distributed to the pilots during the sessions, and they were allowed to fill them in at their leisure.

RESULTS

SYMBOLOLOGY QUESTIONNAIRE. SECTION I

The 45 symbols constructed by each subject were sorted into one of four coding groups based upon the types of elements used in the design of the symbols. The four coding groups were derived empirically based on the ability of the investigators to classify symbol elements. They are as follows:

- Group I — Pictorial, real-world analogies
- Group II — Alphanumeric
- Group III — Simple lines and curves, abstract
- Group IV — Geometric shapes, triangles, rectangles, etc.

The degree of consistency among the subjects may be assessed by means of the entropy, H_R , of the set of symbols where $H_R = -\sum p_i \log p_i$ and p_i is the percent of sample using the i th category and the logarithm is to base ten. (H_R = "non-metric variability of any probability distribution," Garner and McGill, 1956).

Appendix 3 gives H_R values for the college students and the two pilot samples. A high value for H_R indicates high variability and a low value, low variability. The students were significantly more variable than either of the two pilot samples. For example, consider the symbol for aircraft in general: H_R for students was 0.85 while H_R for F-111 and F-15 pilots was 0.44 and 0.55 respectively. The least amount of variability was demonstrated by F-111 pilots on the symbols for Initial Point and Radar Installation with H_R values of 0.32 each. The highest variability was shown by college students on the symbols for designating Enemy, Friendly, and Unknown with H_R values in the range of 1.07 to 1.10. The students were uniformly variable on most symbols but less variable on Ships, Initial Point, and Target. The two pilot samples were equally variable on 34 of the 45 symbols — there being no discernable pattern to the symbols on which they were different.

The H_R values give a good indication of the amount of variability with respect to the different coding styles (Groups I through IV) used by the subjects. In other words, it says how *much* the subjects varied between coding groups while constructing the symbols. It does not, however, indicate *which* coding groups were used more frequently. For instance, one subject might bounce back and forth from Pictorial representations to Alphanumeric representations and have the same H_R as one who used all four coding styles in equal amounts.

In order to determine if coding group preferences were a function of experience, Chi Square values were calculated within and across the frequency distributions of coding groups by symbol using seventeen of the "conceptually independent" symbols. These are the more generic symbols requested of the subject such as Aircraft, Troops, Radar Installation and etc. These were chosen for analysis because it was probable that there would be no mixture of coding group elements in those symbols, i.e., it was likely that each of these symbols could easily be classified into one of the four coding groups because they would have no modifying or dependent elements such as would be required for flight parameters or ordnance carried and so on.

These seventeen symbols and the associated Chi Square values are listed in Appendix 4. Chi Square values greater than 7.82 indicate significance at least at the .05 level. For 13 of the 17 symbols, it was found that students and F-111D pilots have different preferences for coding methods. When students were compared with F-15 pilots, a coding preference was indicated on 8 of the 17 symbols. The coding preference differences were present between the two pilot samples but were definitely less than when compared to student preferences. The two pilot populations differed on 5 of the 17 symbols.

The Chi Square results show that there is a tendency for subjects to prefer different approaches to symbolizing tactical information when their experience is different. Another population stereotype factor is also evident in the measure of variability, H_R , where it was found that students are considerably more variable in their choice of coding methods than are pilots. The actual method preferred by each of the three populations for each symbol is shown in Appendix 5 which is discussed below.

Percentages of each population sample using a particular coding group were calculated and listed for each symbol in Appendix 5. In Coding Group I (Pictorial), for example, 43.4% of students, 9.1% of F-15 pilots, and 2.6% of F-111D pilots constructed Pictorial representations for the symbol Target. Still looking at the

symbol for Target, one does not find a higher percentage of students in any of the other Coding Groups (II, III, IV); therefore, the modal response for students was a Pictorial representation for Target. The highest percentage of F-111D pilots and for F-15 pilots is found under Group IV (Geometric Shapes) for the Symbol Target. These are 89.7% and 54.5%, respectively, and therefore the modal response was Geometric Shapes for both pilot populations.

Also listed in Appendix 5 are the proportions of students and pilots whose symbol designs could not be classified into the four coding groups. Most of these proportions are small but some significant figures are as follows: 68.2% of the F-15 pilots constructed symbols for aircraft which could not be classified into Groups I through IV; 52% of the F-111D pilots and also college students produced symbols for Origin (friendly, enemy, and unknown) which could not be classified into Groups I through IV.

A summary of Appendix 5 is included on the next page (Figure 1) and shows in graphic form the modal responses for each symbol analyzed.

Briefly then, this analysis indicates that the pilots chose to symbolize these conceptually independent information items by using Pictorial representations and Geometric Shapes (Groups I and IV), whereas students chose Pictorial representations and simple lines and curves (Groups I and III) and also, but to a lesser degree, alphanumeric and Geometric Shapes. Overall, most symbols classified fell into Groups I and IV.

The preferred symbol coding methods were then resorted and listed (see Table 1) across population samples and compared to the SSC recommendations. As shown in the table, the pilots' responses were considerably different from the students' and the SSC. Actually, the SSC recommendations agreed more closely with the students' preferred coding methods. These results might suggest that the JTIDS flight test symbol set may cause some problems for pilots.

All of the results discussed thus far have been those related to the symbols which represent generic or conceptually independent entities such as aircraft, ships, troops, etc. A similar analysis was conducted using the auxiliary or conceptually dependent symbols such as types of aircraft, types of ships, and so on.

TABLE 2
PERCENTS OF SAMPLES EMPLOYING VARIOUS CODING CLASSES

CLASSES	PERCENT OF SAMPLE			
	SSC	STUDENTS	F-15 PILOTS	F-111 PILOTS
I — Pictorial	37	32	47	32
I — Alpha-Numeric	13	26	26	11
III — Simple Lines	31	26	0	5
IV — Geometric Shapes	<u>19</u>	<u>16</u>	<u>27</u>	<u>31</u>
	100	100	100	100

Appendix 6 contains the listing of these dependent symbols with proportions of students and pilots who used each of the four Coding Groups (I through IV). In comparing these results with the independent symbols results discussed earlier, students and pilots alike tended to use alphanumeric (Group II) and Simple Lines and Curves (Group III) to code the dependent or additional information; whereas the responses for the independent symbols tended to fall into Pictorial and Geometric classifications (Groups I and IV).

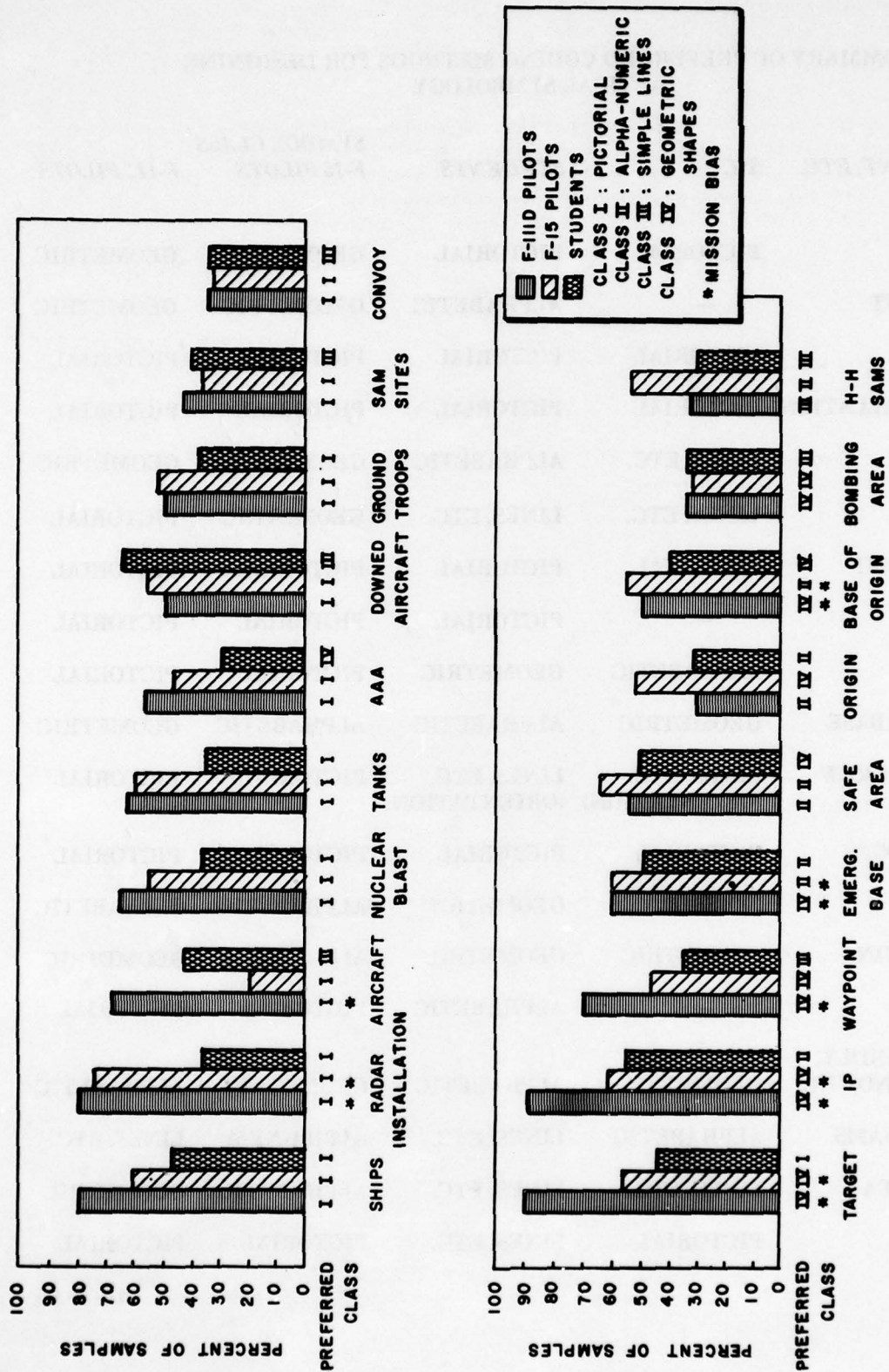


Figure 1. Preferred Coding Methods By Object

TABLE 1

SUMMARY OF PREFERRED CODING METHODS FOR DESIGNING
TACTICAL SYMBOLOGY

OBJECT, EVENT, ETC.	SSC	STUDENTS	SYMBOL CLASS	
			F-15 PILOTS	F-111 PILOTS
TARGET	PICTORIAL	PICTORIAL	GEOMETRIC	GEOMETRIC
INITIAL POINT	—	ALPHABETIC	GEOMETRIC	GEOMETRIC
SHIPS	PICTORIAL	PICTORIAL	PICTORIAL	PICTORIAL
RADAR INSTALLATION	PICTORIAL	PICTORIAL	PICTORIAL	PICTORIAL
WAYPOINT	LINES, ETC.	ALPHABETIC	GEOMETRIC	GEOMETRIC
AIRCRAFT	LINES, ETC.	LINES, ETC.	GEOMETRIC	PICTORIAL
NUCLEAR BLAST	PICTORIAL	PICTORIAL	PICTORIAL	PICTORIAL
TANKS	—	PICTORIAL	PICTORIAL	PICTORIAL
AAA	ALPHABETIC	GEOMETRIC	PICTORIAL	PICTORIAL
EMERGENCY BASE	GEOMETRIC	ALPHABETIC	ALPHABETIC	GEOMETRIC
DOWNED AIRCREW	LINES, ETC. (ORIENTATION)	LINES, ETC. (ORIENTATION)	PICTORIAL	PICTORIAL
GROUND TROOPS	PICTORIAL	PICTORIAL	PICTORIAL	PICTORIAL
SAFE AREA	LINES, ETC.	GEOMETRIC	ALPHABETIC	ALPHABETIC
BASE OF ORIGIN	GEOMETRIC	GEOMETRIC	ALPHABETIC	GEOMETRIC
SAM SITE	—	ALPHABETIC	PICTORIAL	PICTORIAL
ORIGIN (FRIENDLY, ENEMY, UNKNOWN)	GEOMETRIC	ALPHABETIC	GEOMETRIC	ALPHABETIC
HAND-HELD SAMS	ALPHABETIC	LINES, ETC.	ALPHA-NUM	LINES, ETC.
BOMBING AREA	LINES, ETC.	LINES, ETC.	ALPHABETIC	GEOMETRIC
CONVOY	PICTORIAL	LINES, ETC.	PICTORIAL	PICTORIAL

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The dimensions of the symbol designs which resulted from Section I of the Symbology Questionnaire are presented in Appendix 7. Appendix 8 demonstrates how each of the sample populations would have coded each symbol based on the modal responses shown in these analyses.

SYMBOLOGY QUESTIONNAIRE, SECTION II

In Section II of the Symbology Questionnaire, subjects were asked to combine some of their previously constructed symbols into more complex symbols to integrate several levels of information. This task measured their ability to recall symbol responses from Section I and evaluated their "system" for constructing complex symbols. Evaluation of the logic employed to construct complex symbols was not a dependent measure for this analysis and was viewed by the investigators as a potential source of novel, unique, or innovative coding techniques. Recall, however, was a dependent measure and it seems that whatever the pilots were using appeared to work better for them than the technique used by the students. Ninety-two percent of pilots scored 50% or greater on Part 2, while only forty-nine percent of the students did as well.

PERCEPTUAL TESTS

Scores on the two perceptual tests were compared across samples using percent correct as the primary dependent variable. They were positively correlated yielding significant Pearson r values for the F-111D pilots and college students (see Table 3).

TABLE 3
PEARSON r VALUES FOR PERCEPTUAL TEST SCORES

<i>Sample</i>	<i>Rotated Blocks</i>	<i>t</i>	<i>p</i>
College Students (53)	.59	5.22	$p < .01$
F-111D Pilots (39)	.49	3.42	$p < .01$
F-15 Pilots (22)	.32	1.51	$p > .10$
Combined Sample (114)			

The scores were plotted in percentile distributions. The distributions of scores on the Rotated Blocks (see Figure 2) yielded the greatest amount of separation among samples. The two samples of pilots scored significantly higher than the college students on the Rotated Blocks (see Table 3). The F-15 pilots scored higher than the F-111D pilots on the Rotated Blocks test, but the difference was not significant. The students and the two samples of pilots had DAT scores within the same approximate range; therefore, those scores did not appear useful for discriminating between samples. Unlike the DAT scores, the distributions of scores from the Rotated Blocks test enables one to discriminate between population samples, or at the very least between students and pilots. The pilots' scores were much higher and suggest that they would have greater ability to visualize complex relationships. This ability was perhaps reflected in their superior performance on Part 2 of the Symbology Questionnaire.

DISCUSSION

The choice of coding group categories (Groups I through IV) with which to classify the constructed symbols was, admittedly, somewhat arbitrary. It is possible that a different classification scheme would yield somewhat different results. If the classification scheme which was used is assumed to be adequate, then it appears to be effective when distinguishing gross differences in coding methods, e.g., Alphanumeric versus Pictorial. It does, however, cover up many small differences within classes.

DISTRIBUTION OF SCORES ON ROTATED BLOCKS TEST

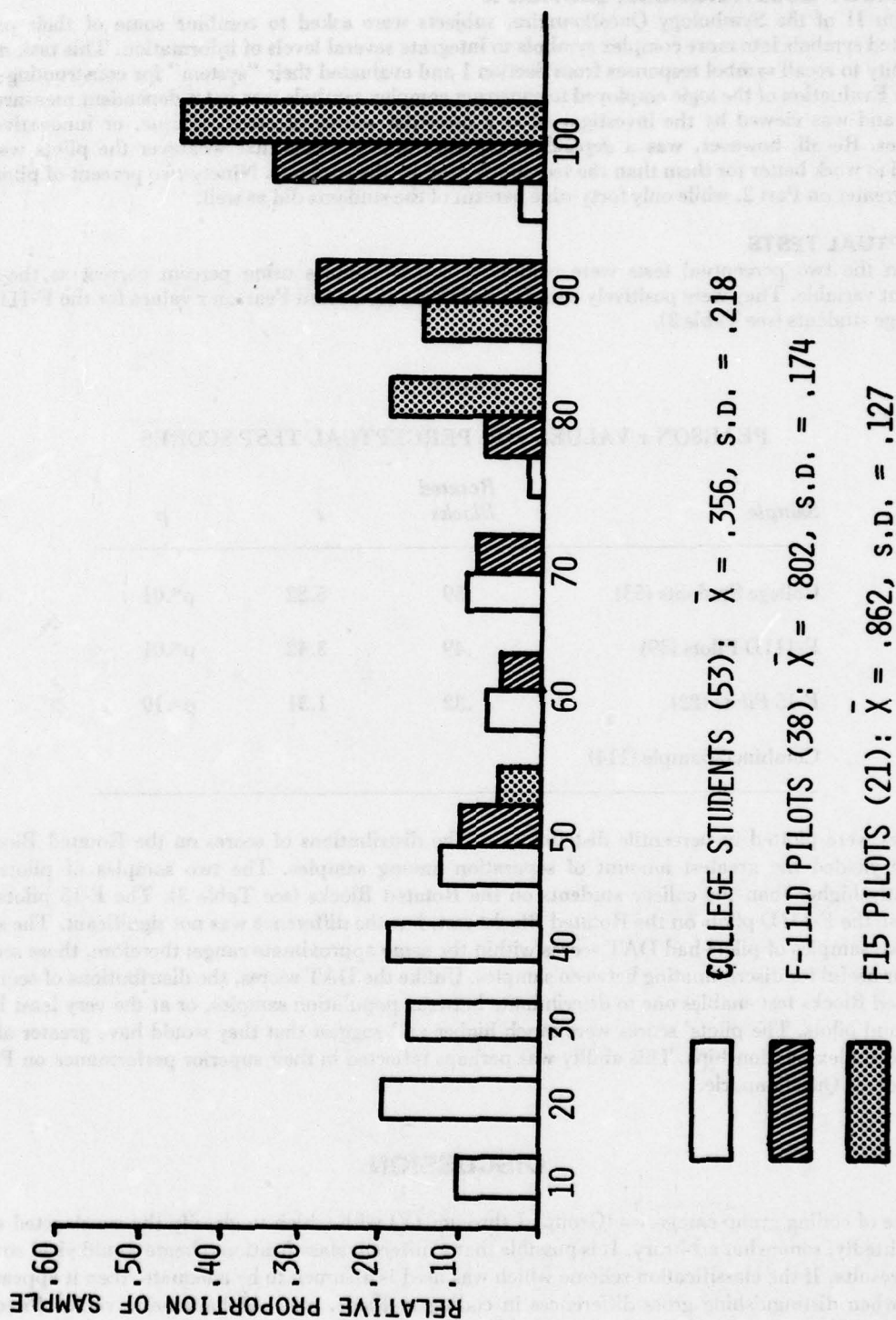


Figure 2. Distribution of Scores on Rotated Blocks Test

In order for these gross differences in coding methods to be meaningful, they must be related to actual performance on the JTIDS, i.e., if subjects prefer Pictorial symbols, their performance while using JTIDS should be at its best when Pictorial symbols are employed. This relationship has not been established by this study. It may be that significant differences in symbol preference do not produce correspondingly significant differences in JTIDS operator performance. This is certainly a subject for further investigation.

Further experiments are currently being planned so that JTIDS performance may be evaluated.

Symbol discriminability will be determined mathematically using a spatial frequency analysis. Approximately 145 symbols (including the SSC symbology) will be analyzed by Dr. Mark Cannon of AMRL.

This same group of symbols is currently being used in a confusability study by Dr. Warren Teichner at New Mexico State University under the auspices of the Air Force Office of Scientific Research. Dr. Teichner will determine empirically the relative confusability of the symbols using college students as subjects.

Mr. Pearson is using this 145-symbol set in another study to determine the relative association values of different symbols for the same object. Response time and errors are the primary dependent variables used to determine how easily and how well an association is learned and how rapidly it can be recalled.

Results of these studies will be applied as they become available to evolve a "Best" symbol set to be used in a JTIDS/Pilot performance experiment. A JTIDS simulator, currently being installed by ASD/EN, will be used to evaluate pilot performance under realistic workload conditions involving real-world Head-Up and Head-Down tasks. The evolving "Best" symbol set will be compared to the SSC symbol set using several mission types and different difficulty levels of flight task and JTIDS information load.

CONCLUSIONS

The results from this survey of pilots and college students using a symbology questionnaire requiring all participants to design sets of complex codes to represent tactical information demonstrated that there are marked differences in symbol design preferences between college students and pilots. The results demonstrate that there are population stereotype effects on symbol design preference (Section I of the Symbology Questionnaire) and also effects on ability to recall and integrate various levels of information when composing a more complex symbol (Questionnaire Section II).

The data suggest that, at least, a rather small sample of the potential JTIDS users, pilots, prefer a symbol coding strategy which is significantly different from that proposed by the Symbology Standardization Committee. The significance of this difference has yet to be determined and should be pursued via learning and man-in-the-loop experiments and JTIDS simulations.

Based on pilot opinions expressed in the group discussions and also based on statistical evidence resulting from the analyses in this study, a more nearly optimized symbol set for Air Force Tactical Fighter Pilots should be designed considering the following factors: (1) symbols should be as realistic or pictorial as possible to minimize recognition and information translation time, (2) existing symbols for tactical navigation, e.g., Waypoint (or Checkpoint, or Turnpoint), Initial Point, Target, should be used to represent the same entities they have been associated with in the past, and (3) the symbol set should be standardized at the highest level practicable.

SCORES BY SAMPLE PERCEPTUAL TESTS (MAX = 1.0)

Sample	Rotated Blocks		D.A.T.		<i>t</i>	<i>P</i>
	<i>X</i>	<i>s.d.</i>	<i>X</i>	<i>s.d.</i>		
College Students	.356	.218	.605	.156		
F-111D Pilots	.802	.174	.759	.146	11.32	<i>P</i> < .01
F-15 Pilots	.862	.127	.736	.115	12.52	<i>P</i> < .01

APPENDIX 1

QUESTIONNAIRE AND PERSONAL DATA SHEET







SYMBOLGY QUESTIONNAIRE

INTRODUCTION

This questionnaire will give you an opportunity to recommend symbol formats for use on radar-type cathode-ray-tube (CRT) displays. You will create symbols to represent tactical information, such as aircraft, missiles, ships, etc. This task will require you to use both imagination and analytical thinking to project how a pilot would perceive these symbols on a display. For example (see Figure 1), would you readily associate it with an airplane?

Some persons responding to this questionnaire will not have had any aircrew experience with CRT displays in a cockpit. We apologize to the experienced persons for reading this but some information is necessary for the non-experienced respondents. The rest of this paragraph is for them. Several considerations must be made when designing symbols for these displays. (1) One important restriction influencing symbol formats is the size of the CRT display. Often its area is less than 18.6 square inches (6 inch diameter CRT face). This area might represent 20 square miles. Therefore, the size of the display restricts the fidelity of the symbols. (2) The 'state-of-the-art' in CRT technology versus the cost of the display system influences the symbol formats; and (3) High pilot workload leaves less time to read and interpret these symbols.

Frequently it is necessary to use several dimensions of a symbol to encode adequate information to describe a potential threat. We would like to show you what we mean without stifling your creativity because we will need *your own ideas* of what are good symbols for various categories of tactical information. So, let us use an example here from a different area to illustrate what we mean.

Suppose we wish to indicate symbolically one of these different cars — Chevy, Ford, or Plymouth; one of these body styles — sedan, station wagon, or sports car; and one of these horsepower — 0—150, 150—200, or 200—400. We use *C* for Chevy, *F* for Ford, and *P* for Plymouth (later on in this test the concept "designator category" will be defined as an indication of origin; this scheme previously described is an example of "designator category"). We use  to represent a sports car, a  for a sedan, and a  for a station wagon. The number of wheels will indicate the horsepower of the vehicle. Therefore, *C*  is a Chevy sports car with a 0—150 h.p. engine; a *F*  is a Ford station wagon with 150—200 h.p.; and a *P*  is a Plymouth sedan with 200—400 h.p. So, you can see how a compound symbol can be constructed from several logically consistent parts.

There is a limit to the amount of information which can be represented on a symbol. The more complex the symbol (complex meaning the amount or the number of components of information), the higher the workload. The pilot has little time, sometimes less than a second, to view the display; therefore the complexity of the symbol versus the amount of salient information it represents impacts upon his workload. For non-pilots and those unfamiliar with the concept of workload when applied in the cockpit environment, an analogy is provided below.

Imagine yourself driving a car at a high speed in fairly busy traffic. You have a CRT display on your instrument panel within viewing proximity of the speedometer. The symbols you will create are to be displayed on this CRT. You will be required to recognize these symbols, interpret the information, and make some appropriate response independent of controlling the car safely in the heavy traffic.

This description should help you appreciate symbol design problems associated with reducing operator workload.

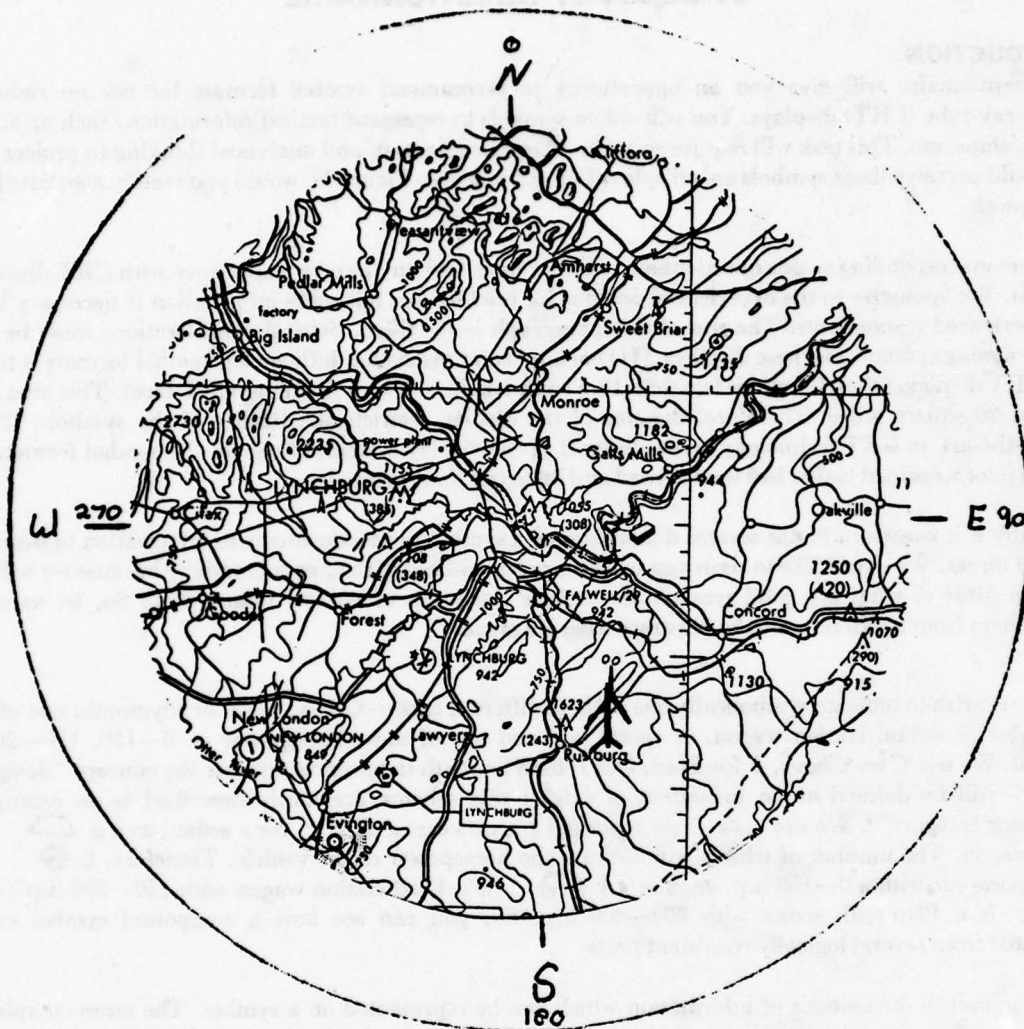




Figure 1. Hypothetical Radar Display

This questionnaire is divided into several sections. They are as follows: (A) The *Introduction* which you have just completed; (B) the *Guidelines* which describe the task of creating symbols; (C) the *Restrictions* section lists the criteria which you must conform to when creating symbols; (D) *Suggestions*; and (E) the *Test*. Be sure to read these sections *very carefully*. If you have any questions, ask the test monitor before you begin the test.

GUIDELINES

1. The identity of a symbol on radar-type display systems fall into one of three classifications: friendly, unknown, or enemy. These three types will be referred to as "designator categories" because these identify the origin of the potential threat. Geometric shapes are commonly used to define each designator category. Often only part of the shape is used, for example two sides of a triangle with a dot in its center , might represent a friendly tank. The orientation of the designator shape remains constant, but any additional symbol within it might change in orientation.
2. You may use *all* or *part* of the shape to create a symbol. Since your response is limited to a 3/8 inch square, it may not be advantageous to use the entire shape.
3. There are several general categories of targets to be represented symbolically. You are to design these so that they can be systematically modified to facilitate representation of additional material. For example, if represented a friendly aircraft, then a friendly bomber could then be represented by  — a modification of the general symbol. Keep in mind that the symbol designs must be systematic so that they can be integrated into a more complex symbol. Design the symbols using a "building block" approach.
4. The additional dimensions of information you add to the symbol to further define the target must remain constant across designator categories.

RESTRICTIONS


1. No more than eight connected lines can be used in designing a basic component of information or a designator category; a circle is considered as one line.
2. The symbol and its designator category must be drawn within a 3/8 inch square area. A square is provided for you to maintain uniform responses under each category.
3. Neither color, brightness, or shading can be used as coding dimensions.
4. Symbols must be the same across designator categories, i.e., a symbol for a bomber symbol would be the same for friendly, enemy, or unknown, except that the designator shape would change accordingly. This restriction minimizes the number of symbols the pilot will have to learn and therefore reduce confusability.

SUGGESTIONS

1. Keep the symbol designs simple.
2. If you are not sure about the legibility of a symbol, hold the paper at arms length and make sure you can clearly see all the dimensions of coded information.
3. You may use alpha-numeric numbers in conjunction with the symbolic representation.
4. You use no more than four lines of alpha-numeric code in proximity of the symbol for abbreviated coding of information. These lines of code should fall within a 1/2 inch square area. Remember, the use of alpha-numeric is *optional*.

SECTION 1

CODE _____

Design symbols for the different categories listed below. Remember to keep them simple using no more than 8 lines per component of information. Make your responses in the squares adjacent to its description. Design your own designator category using a maximum of 8 lines. Read through the list of stimuli before making a response. You may change a response at any time.  is the actual display size.

Designator Categories**Friendly****Unknown****Enemy****I. Aircraft (In General)****A. Aircraft Type****1. Fighter**☐☐☐**2. Bomber**☐☐☐**3. Helicopter**☐☐☐**4. Transport**☐☐☐**5. Forward Observer**☐☐☐**6. Reconnaissance**☐☐☐**7. Electronic Jammer**☐☐☐**8. Tanker**☐☐☐

Designator Categories

Friendly

Unknown

Enemy

**B. Aircraft Armament
(Draw on an Aircraft)**

1. Air-to-Ground (In General)

☐☐☐

a. Guided Nuclear

☐☐☐

b. Guided Conventional

☐☐☐

c. Freefall Nuclear

☐☐☐

d. Freefall Conventional

☐☐☐

2. Air-to-Air (In General)

☐☐☐

a. Guided Nuclear

☐☐☐

b. Guided Conventional

☐☐☐

c. Unguided (Rx, Gun)

☐☐☐

Designator Categories

Friendly

Unknown

Enemy

**C. Flight Parameters
(Draw on an Aircraft)**

1. Altitude = 10,000'

☐☐☐

2. Heading = 270°

☐☐☐

3. Airspeed = 500 Knots

☐☐☐

II. Ships (In General)

A. Type

1. Aircraft Carrier

☐☐☐

2. Tanker

☐☐☐

3. Destroyer-Battleship

☐☐☐

4. Missile Ship

☐☐☐

5. Submarine

☐☐☐

Designator Categories

Friendly

Unknown

Enemy

III. Ground Targets

A. Artillery & Antiaircraft

☐☐☐

B. Troops

☐☐☐

C. Tanks

☐☐☐

D. Convoy

☐☐☐

E. Radar Installation

☐☐☐

F. SAM Site (Surface-to-Air Missile Site)

☐☐☐

1. Hand Held Sams

☐☐☐

2. SA-7 and SA-8

☐☐☐

IV. Miscellaneous

A. Safe Area

☐☐☐

Designator Categories

	Friendly	Unknown	Enemy
B. Base of Origin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. Nuclear Blast	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Bombing Area	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Downed Aircrew	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. IP (Initial Point)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. TGT (Target)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Waypoint	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Emergency Base	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

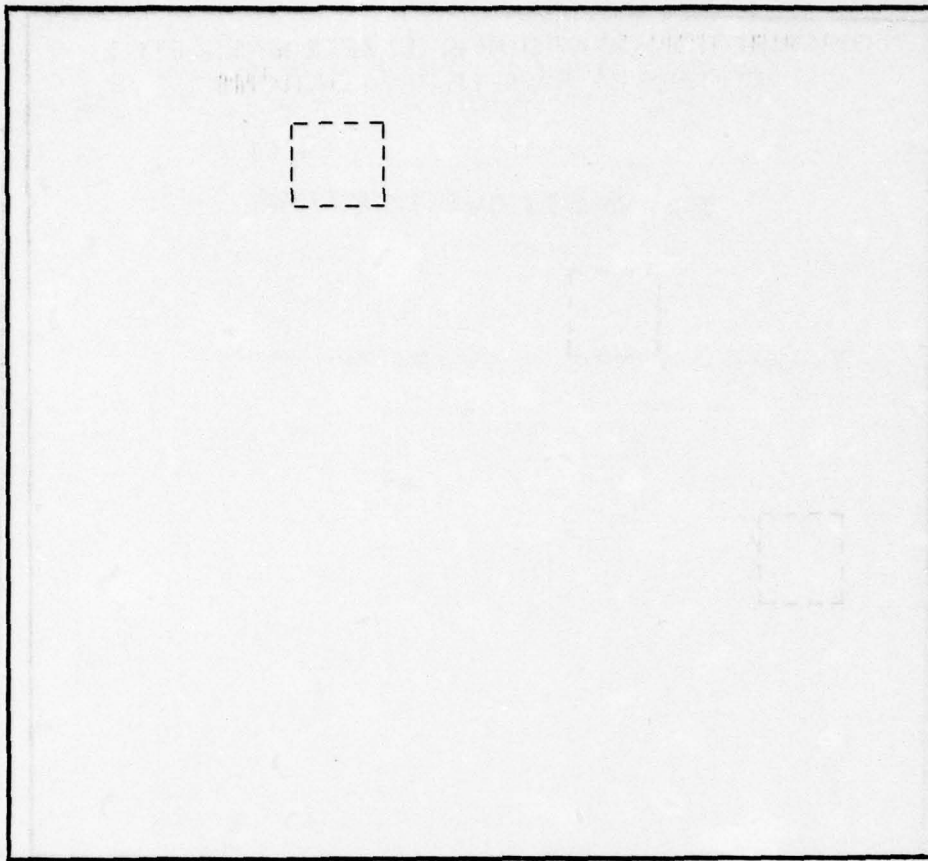
SECTION 2

CODE _____

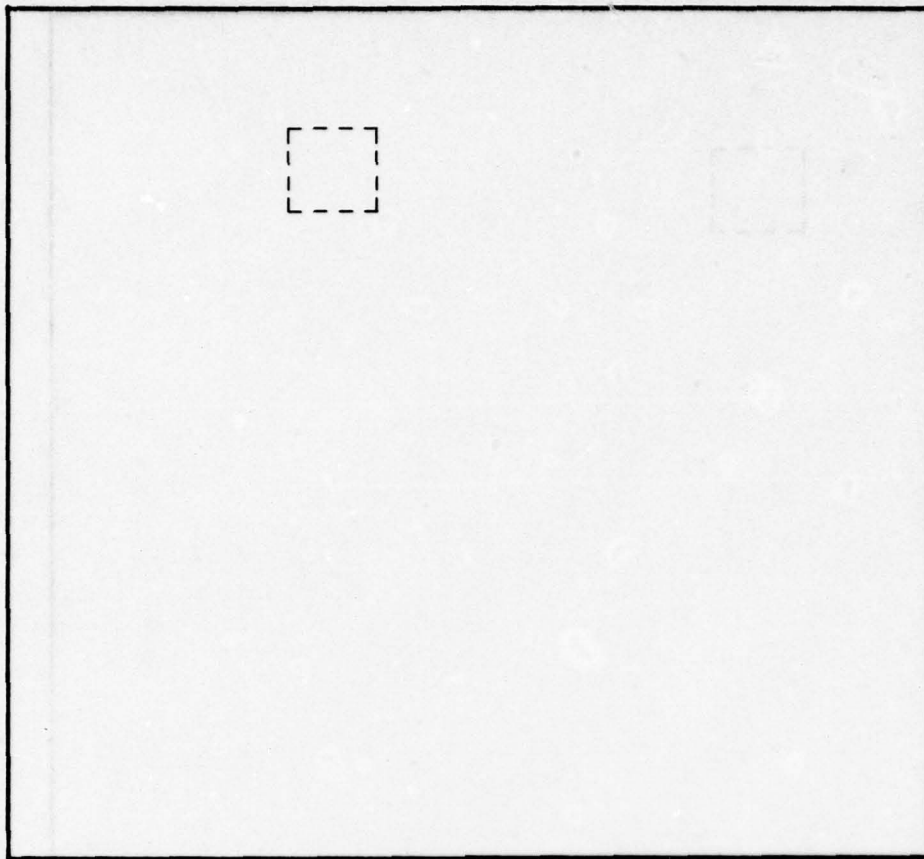
SYMBOLOLOGY QUESTIONNAIRE

Directions

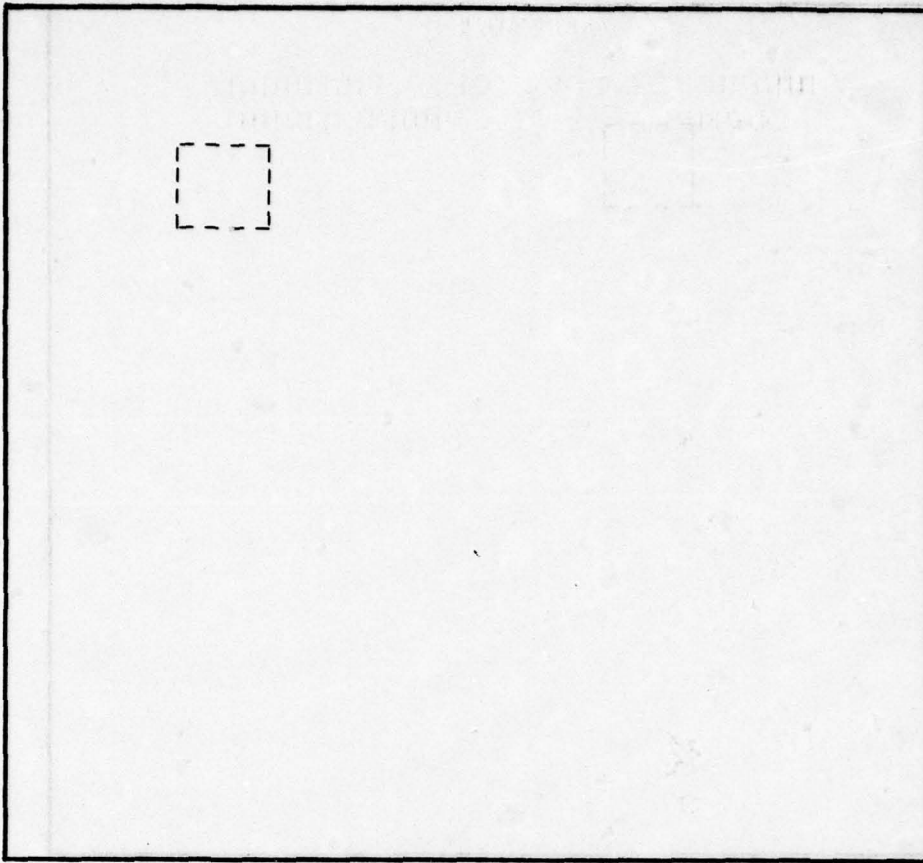
In this section you will reproduce some of the symbols that you previously created.



3. Draw a symbol which represents an unknown aircraft carrier traveling west at a slow rate of speed (30 knots).



4. Draw a symbol which represents an unknown aircraft carrier traveling west at a slow rate of speed (30 knots).



5. Draw a symbol which represents an unknown bomber heading 90° at 250 knots carrying conventional stores.

PERSONAL DATA SHEET

Name: _____

Formal Education: _____

Rank: _____

Age: _____

Present Assignment: _____ A.F.B.

Autovon Number: _____

Pilot Experience:

Aircraft Type

Hours

_____	_____
_____	_____
_____	_____
_____	_____

Estimated Leave and TDY Schedule

Leave Date

Return Date

_____	_____
_____	_____
_____	_____
_____	_____

Do you desire anonymity? yes no Circle one

***Return this sheet with Consent Form in the self-addressed envelope.**

APPENDIX 2


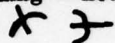

GROUP DISCUSSIONS

The pilots were asked 11 questions related to the JTIDS symbology following a briefing on the SSC's symbols. These are listed below, along with the responses.



1. How would you compare the SSC's standard symbol set with your set?






F-111D Pilots

Group 1


Should, as much as possible, stick with "the standard symbols" (used in TAC map annotation), a square for IP, a triangle for target and the  symbol for a radar offset point. Should use a gun barrel for artillery, an airplane for aircraft (more graphic symbols), symbols that look like what they represent. If half circle with heading line is used for aircraft — should have the capability of rotating entire symbol to show heading — not just rotation of heading line. Thus, the symbol would look like an airplane all the time, i.e., this  instead of this .


Group 2

Don't particularly care for them (the SSC symbol set). Symbols should look like what they represent. The boat () or the man () is more along that line.

Seems ridiculous to have symbols representing friendly aircraft. When you look at the scope (under stress, high workload) everything is gonna look like the enemy. It makes more sense to not display friendly aircraft. The symbol for friendly — if you're going to use a curved circle — should be smiling () instead of () frowning.  is currently map symbol for (offset aiming point) OAP, and  is target symbol.  is for IP.

Group 3

Why the departure from the standard target symbol () which has been used for years?

Symbol for aircraft (SSC) is not readily interpreted. Perhaps an elongated delta would be better. Don't think the homeplate symbol () is necessary. You know where homeplate is.

(General agreement that alpha characters for designating type of aircraft, e.g., K-tanker, A-attack, B-bomber, Q-drone, are fairly well standardized and useable).

F-15 Pilots

They (SSC) are simpler because there is less information shown there. We were under the impression (from the questionnaire) that a symbol should be capable of indicating all the information aspects at one time for all targets, i.e., type aircraft, airspeed, heading, altitude, forward firing ordnance, missiles, bombs, and etc. The (SSC) symbols are all right the way they are, especially if that information can be read out when requested (abbreviated information at bottom of CRT presented when target symbol is interrogated using the acquisition symbols). I would hate think, in the multi-bogey environment, of all the information being displayed on each symbol — you'd have nothing but garbage.

In the interests of reducing the number of symbols — if there are only three categories (friendly — just don't show anything. (For an unknown aircraft — just the basic aircraft symbol — implication being that any unknown would be represented by the basic symbol without either a friendly or enemy category designator).

One thing about the symbol for aircraft — the dot with the velocity vector (\nearrow), what happens if you have target without a velocity vector (vector unknown) you'd just end up showing the dot and you might miss it.

One thing I'd like to see, talking about ordnance on the aircraft — I don't think it's necessary to have a code for specific types of ordnance — if we could have a code (symbol) that indicated the target had a forward firing ordnance capability, regardless of type, I think I'd rather see that coded on the target symbol rather than having to call it up (interrogate the symbol and get abbreviated information readout). Two symbols for enemy fighters — one showing forward hemisphere attack capability, the other showing rear hemisphere attack capability. The target's attack capability has an immediate effect on the tactics I would employ. (NOTE: These pilots responded to most questions as if they were only concerned with the air superiority, or air-to-air combat role — their primary mission in the F-15).

In reference to the heading vector there — would it be possible to graduate it in terms of groundspeed? If the target's groundspeed is 600 kts., you would have a vector of say X units in length. If another target were going 300 kts., the vector would be X/2 units long.

2. Would you prefer your own customized set?

F-111D Pilots

Group 1

You might have to provide a few optional symbols for a particular aircraft. Standardized symbols are most probably the way to go. Should be standardized at least on the Wing (AF organizational unit) level.

Group 2

Need to have symbols standardized. Money for a custom input feature would probably be wasted. Feature would probably not be used.

Group 3

Standardized set is better.

F-15 Pilots

No. Symbols are simple enough. There is a lot of information that just isn't there — depending on what you need. For example, the symbol for a ship — no problem recognizing what it is — but we would be interested in knowing whether it had surface-to-air missile capability. I would like to see an extension to the symbology. There is a certain amount of more information that should be depicted but there's no need for all the available information to be depicted.

3. *Are the standard symbols overloading you with information?*

F-15 Pilots

No. Too difficult to talk about symbols without a common base. Should be standardized across Department of Defense or across users.

F-111D Pilots

Group 1

Yes, would overload especially in Eastern European scenario where the scope would be flooded with symbols.

Group 2

Aircrew is saturated with information — only has time for a quick look at scope. Symbols are too complicated — you have to sit there and “read” them.

Group 3

(In answer to “. . . are the SSC symbols too complicated?") The standard Army symbol for troops is just an X. You get so many symbols from RHAW system and etc., that at times the information can be detrimental.

4. How would you best interact with the CRT display? Remote switches? *Push-buttons on the dashboard around the CRT?*

F-111D Pilots

Group 1

Pushbuttons around the scope.

Group 2

Pushbuttons — unanimously.

Group 3

Dedicated pushbuttons.

F-15 Pilots

Dedicated pushbuttons around the CRT.

5. *Would you want audio tones for attention getting?*

F-111D Pilots

Group 1

(No) You're going to have so many audio tones . . . General — must have real-time (from on-board sensors) radar warning information displayed on scope. RHAW set should be integrated into the JTIDS display for sure.

Group 2

Definitely NO. Only when something catastrophic is fixing to happen.

Group 3

You would be busy with a lot of different things. (Generally mixed feelings — could work if tone system was simplified and integrated with other tone systems).

F-15 Pilots

No audio tones — too many already.

6. *What are your feelings on using a helmet mounted display to present JTIDS info?*

F-111D Pilots

Group 2

No. Too distracting — jitter and flashing lights.

Group 3

No. All you would need is for that thing to act up at a critical time and you would go blind. No way. It might not be a bad idea. Anything you put on a helmet is going to add weight. We've had experience with the bird-proof helmet — it was so heavy it about broke your neck. I don't think that's a good idea at all — anything like that could possible blind you with a malfunction — or anything like that could screw up your mission when you should be looking outside the cockpit for missiles being launched

F-15 Pilots

Would rather have JTIDS display on CRT on instrument panel. Might like to have warnings such as "check six" or "attack" flashed on helmet mounted display for imminent threats or, in like manner, "shoot" when weapon system is within kill parameters on an attack.

7. *Would you want JTIDS info on a Heads Up Display [HUD]?*

F-111D Pilots

Group 2

No

Group 3

No way. Absolutely not . . . couldn't see . . . too much garbage on HUD's now. You wouldn't be able to read any of that through the HUD.

F-15 Pilots

I wouldn't want anything that would degrade my eyesight at all. The HUD (Heads Up Display) itself has got enough garbage on it.

Would not want JTIDS info on the HUD.

8. *In what priority would you rank various hostile threats such as, AAA, SAMS, small arms, enemy fighters, etc.?*

F-111D Pilots

Group 1

It would be dependent on the type of mission and type of aircraft. For low-level, terrain following, strike — SA 7's, SA 9's, Quad 23's before hostile aircraft. Scope range should be automatically variable to display imminent threats.

Group 2

Ground or Surface-to-Air threats first. Depends on your type of mission and aircraft. Crew should be able to select, on each mission, the threat priorities. Day VFR, single seat, ground attack in a mixed threat: AAA, SAMS, then fighters. Priority should depend on altitude of your aircraft also.

Group 3

(Single Seat, Day VFR, ground attack) — still doesn't necessarily limit the way threats are ranked. You might be in an A-10 or something slower than that where an SA-7 might bother you — where if you were in a faster single-seat aircraft an SA-7 wouldn't concern you.

Scope should display only immediate threats to you. If it's not within range or not shooting at you — you shouldn't see it. (Disagreement here:) I disagree — you might be flying into a SAM site and not know it.

F-15 Pilots

Should be consistent with other warning equipment (EWEWS, TEWS, RWR, RHAW) being used on the aircraft. Will be mission dependent. Should have some means of selecting the threat priority according to altitude of operation.

9. *If some threat priority system is used, what maximum number of symbols should be displayed in the proposed 5" X 5" CRT area?*

Group 2

Do you really think that the system would be useable in a high density area? There would be too many symbols to be useable. You would have to try to avoid the real bright (on the scope) areas.

Group 3

In an Eastern Europe scenario the JTIDS would be lit up like a Christmas tree — like our RHAW scope is now.

10. *When using JTIDS for navigation, would you need additional symbols [other than course lines and waypoints] to help keep you geographically oriented?*

F-111D Pilots

Group 1

Would like to have JTIDS map superimposed on moving map (current F-111D) display.

Group 2

As far as we're concerned, it's pretty important to know if there's a hill between us and where we're going.

11. *i.e., would additional information on the scope be helpful in finding a ground target, locating a FAC, station keeping and etc.?"*

F-111D Pilots

Group 1

If you're told to hold over a bridge (for example) it sure would be nice to have it on the display.

F-15 Pilots

I would think for a low-level bomb dropper — he would be interested in altitudes on each leg and terrain elevation.

I can't see that it would be very reliable, that it would have a very high confidence level. An air-to-ground type flying VFR low-level is going to be looking outside the cockpit all the time — I can't see him trusting the CRT information.

The 320nm scale wouldn't be worth a damn for precise navigation. You would have to get an awful lot of information on there before the CRT would be as useful as a low-level chart.

Could you select a nav leg and have the leg profile displayed on the bottom of the scope?

Would like to have orbit points, AWACS and tanker tracks, CAP (Combat Air Patrol) tracks and etc. displayed.

12. *Does JTIDS have the potential to ease your present workload? If so, how?*

F-111D Pilots

Group 2

(Silence — pondering). If you have time to look at it, if the information is good — (some potential for easing workload).

Group 3

My first impression is that this thing is going to be too complicated for the task loading the pilot already has in a single seat aircraft — too demanding. I'd go along with that and say it's not worth the cost — in our experience with "Super-sophisticated equipment" in this airplane and recent experience with sensors in Task Force Alpha add up to the fact that they're not so reliable — tend to ignore it altogether. Probably would save your money if you gave us some good RHA gear and a simple airplane.

This thing is a nice-to-know, have thing but if you're working radar and other things plus setting up weapons and flying the airplane it's going to be tough to look at anything else — I flew the Thud (F-105) and we had our own radar and doppler and all this other stuff so we had a lot of things to be playing with plus setting up weapons and flying the airplane, flying information — and something like that (JTIDS) — I don't think you'd ever look at it.

Could ease workload if it only gave you threats that were within range.

F-15 Pilots

Would not ease the present workload — would give you a lot more information. Would increase your situational awareness. It might double your workload but if it increases the effectiveness of your weapon system — well fine. It's going to make you busier but you should be able to do a better job.

APPENDIX 3

LISTING STIMULI AND ASSOCIATED HR

No.	Stimulus	STU	F111	F15	No.	Stimulus	STU	F111	F15
1	Friendly	1.08	.74	.87	24	Aircraft Carrier	.99	.63	.62
2	Unknown	1.10	.82	.88	25	Tanker	.91	.67	.79
3	Enemy	1.07	1.01	.91	26	Destroyer	.87	.66	.65
4	Aircraft (In General)	.85	.44	.55	27	Missile Ship	.91	.72	.61
5	Fighter	1.01	.77	.71	28	Submarine	.98	.70	.60
6	Bomber	.99	.77	.73	29	AAA	1.02	.52	.49
7	Helicopter	.95	.72	.70	30	Troops	.95	.69	.65
8	Transport	1.00	.77	.57	31	Tanks	.97	.51	.57
9	Forward Observer	1.00	.92	.69	32	Convoy	1.00	.78	.83
10	Recon	.92	.62	.71	33	Radar Installation	.87	.32	.36
11	Electronic Jammer	1.01	.69	.61	34	SAM Site	1.04	.77	.74
12	Tanker AIR-TO-GROUND	1.02	.70	.74	35	Hand Held SAMS	1.02	.89	.54
13	Guided Nuclear	.99	.76	.73	36	Mobile SAMS	1.00	.83	.36
14	Guided Conventional	.89	.72	.66	37	Safe Area	1.01	.69	.50
15	Freefall Nuclear	.95	.71	.55	38	Base of Origin	1.04	.86	.59
16	Freefall Conventional AIR-TO-AIR	.90	.69	.54	39	Nuclear Blast	.78	.60	.57
17	Guided Nuclear	.94	.81	.66	40	Bombing Area	1.05	.86	.86
18	Guided Conventional	.99	.64	.55	41	Downed Aircrew	.87	.70	.48
19	Unguided	1.09	.79	.63	42	Initial Point	.73	.32	.63
20	Altitude	1.00	.33	.24	43	Target	.73	.41	.73
21	Heading	1.00	.61	.36	44	Waypoint	.87	.70	.72
22	Airspeed	.98	.57	.29	45	Emergency Base	.85	.62	.52
23	Ships (In General)	.72	.37	.52					

APPENDIX 4

CHI SQUARE VALUES COMPARING CODING GROUP DISTRIBUTIONS ACROSS SAMPLES

SYMBOL:

		STD	F-111	F-15
Safe Area	STD	—	8.18*	20.22***
	F-11		—	8.44
	F-15			—
Base of Origin	STD	—	6.39*	8.69*
	F-111		—	3.23
	F-15			—
Nuclear Blast	STD	—	9.75*	3.84
	F-111		—	.250
	F-15			—
Bombing Area	STD	—	8.01*	3.80
	F-111		—	.280
	F-15			—
Downed Aircrew	STD	—	26.11**	22.35***
	F-111		—	2.10
	F-15			—
Initial Point	STD	—	56.82**	23.23***
	F-111		—	7.58**
	F-15			—

*p < .05

**p < .01

***p < .001

		<i>STD</i>	<i>F-111</i>	<i>F-15</i>
Target	STD	—	57.31***	23.23***
	F-111		—	7.58**
	F-15			—
Waypoint	STD	—	47.69***	6.38*
	F-111		—	18.71**
	F-15			—
Emergency Base	STD	—	23.18***	.001
	F-111		—	4.47*
	F-15			—
Aircraft	STD	—	20.74**	9.95*
	F-111		—	13.23**
	F-15			—
Ships	STD	—	11.03**	1.46
	F-111		—	2.91
	F-15			—
AAA	STD	—	1.60	9.14*
	F-111		—	.68
	F-15			—
Troops	STD	—	1.60	3.76
	F-111		—	.19
	F-15			—
Tanks	STD	—	6.22*	3.52
	F-111	—	—	.04
	F-15			—

* $p < .05$

** $p < .01$

*** $p < .001$

		STD	F-111	F-15
Convoy	STD	—	9.70*	1.65
	F-111		—	.02
	F-15			—
Radar Installation	STD	—	18.80***	11.44**
	F-111		—	.36
	F-15			—
SAM Site	STD	—	14.80**	4.87
	F-111		—	.30
	F-15			—

*p < .05
 **p < .01
 ***p < .001

APPENDIX 5

DISTRIBUTION OF GROUP I (PICTORIAL) CODES BY SAMPLE PROPORTIONS

Object, Event, etc.	Students	F-15 Pilots	F-111 Pilots
Target	43.4	9.1	2.6
Initial Point	0	0	0
Ships	45.3	59.1	79.5
Radar Installation	35.8	72.7	79.5
Waypoint	0	4.5	2.6
Aircraft	20.8	18.2	66.7
Nuclear Blast	37.7	54.5	64.1
Tanks	34.0	59.1	61.5
AAA	24.5	45.5	56.4
Emergency Base	9.4	0	2.6
Downed Aircrew	7.5	54.5	48.7
Ground Troops	37.7	50.0	48.7
Safe Area	3.8	0	0
Base of Origin	1.9	0	7.7
Sam Site	9.4	36.4	41.0
Origin (friendly, enemy, unknown)	0	0	0
Hand-Held Sams	11.3	22.7	23.1
Bombing Area	13.2	22.7	20.5
Convoy	15.1	31.8	33.3

**DISTRIBUTION OF GROUP II (ALPHA-NUMERIC)
CODERS BY SAMPLE PROPORTIONS**

<u>Object, Event, etc.</u>	<u>Students</u>	<u>F-15 Pilots</u>	<u>F-111 Pilots</u>
Target	22.6	31.8	2.6
Initial Point	56.6	40.9	10.3
Ships	0	0	0
Radar Installation	17.0	18.2	12.8
Waypoint	47.2	36.4	5.1
Aircraft	0	0	0
Nuclear Blast	26.4	22.7	5.1
Tanks	18.9	18.2	17.9
AAA	20.8	36.4	28.2
Emergency Base	49.1	59.1	28.2
Downed Aircrew	18.9	31.8	20.5
Ground Troops	11.3	18.2	20.5
Safe Area	20.8	63.6	51.3
Base of Origin	22.6	54.5	25.6
Sam Site	26.4	27.3	20.5
Origin (friendly, enemy, unknown)	30.3	27.3	29.3
Hand-Held Sams	26.4	54.5	23.1
Bombing Area	26.4	27.3	28.2
Convoy	22.6	18.2	28.2

**DISTRIBUTION OF GROUP III (SIMPLE LINES, ETC.)
CODERS BY SAMPLE PROPORTIONS**

<u>Object, Event, etc.</u>	<u>Students</u>	<u>F-15 Pilots</u>	<u>F-111 Pilots</u>
Target	17.0	4.5	2.6
Initial Point	9.4	0	0
Ships	11.3	9.1	7.7
Radar Installation	11.3	9.1	5.1
Waypoint	34.0	4.5	5.1
Aircraft	41.5	4.5	7.7
Nuclear Blast	22.6	0	12.8
Tanks	20.8	9.1	2.6
AAA	24.5	18.2	7.7
Emergency Base	22.6	0	5.1
Downed Aircrew	64.2	0	17.9
Ground Troops	26.4	22.5	17.9
Safe Area	18.9	22.7	7.7
Base of Origin	26.4	4.5	5.1
Sam Site	39.6	22.7	20.5
Origin (friendly, enemy, unknown)	0	18.2	0
Hand-Held Sams	30.2	18.2	33.3
Bombing Area	32.1	13.6	7.7
Convoy	32.1	18.2	7.7

**DISTRIBUTION OF GROUP IV (GEOMETRIC SHAPES)
CODERS BY SAMPLE PROPORTIONS**

Object, Event, etc.	Students	F-15 Pilots	F-111 Pilots
Target	11.3	54.5	89.7
Initial Point	28.3	51.9	87.2
Ships	18.9	9.1	5.1
Radar Installation	26.4	0	2.6
Waypoint	7.5	45.5	69.2
Aircraft	13.2	9.1	5.1
Nuclear Blast	11.3	13.6	12.8
Tanks	20.8	4.5	2.6
AAA	28.3	0	10.1
Emergency Base	9.4	31.8	59.0
Downed Aircrew	1.9	9.1	10.3
Ground Troops	18.9	4.5	10.3
Safe Area	49.1	0	30.8
Base of Origin	39.6	40.9	48.7
Sam Site	18.9	13.6	12.8
Origin (friendly, enemy, unknown)	17.3	50.0	8.7
Hand-Held Sams	22.6	4.5	10.3
Bombing Area	22.6	31.8	33.3
Convoy	30.2	31.8	28.2

DISTRIBUTION OF UNCLASSIFIED CODERS BY SAMPLE PROPORTIONS

<u>Object, Event, etc.</u>	<u>Students</u>	<u>F-15 Pilots</u>	<u>F-111 Pilots</u>
Target	5.70	0	2.5
Initial Point	5.70	7.2	2.5
Ships	24.5	4.5	7.7
Radar Installation	9.5	0	0
Waypoint	11.3	9.1	18.0
Aircraft	24.5	68.2	12.8
Nuclear Blast	2.0	9.2	12.9
Tanks	5.5	9.1	15.4
AAA	1.9	0	0
Emergency Base	9.5	9.1	5.1
Downed Aircrew	7.5	4.6	2.6
Ground Troops	5.7	0	2.6
Safe Area	7.4	13.7	10.2
Base of Origin	9.5	0	12.9
Sam Site	5.7	0	5.2
Origin (friendly, enemy, unknown)	52.4	4.5	52.0
Hand-Held Sams	9.5	0	10.2
Bombing Area	5.7	4.6	10.3
Convoy	0	0	2.6

APPENDIX 6

DISTRIBUTION OF GROUP I (PICTORIAL) CODERS BY SAMPLE PROPORTIONS

Object, Event	Students	F-15 Pilots	F-111D Pilots
<i>Aircraft</i>			
Fighter	1.9	27.3	12.8
Bomber	3.8	13.6	10.3
Helicopter	5.7	27.3	35.9
Transport	5.7	4.5	10.3
Forward Observer	3.8	31.8	12.8
Reconnaissance	1.9	18.2	5.1
Electronic Jammer	5.7	4.5	25.6
Tanker	15.1	22.7	20.5
<i>Weapons: Air-to-Ground</i>			
Guided Nuclear	3.8	0	5.1
Guided Conventional	5.7	0	5.1
Freefall Nuclear	1.9	0	2.6
Freefall Conventional	3.8	0	5.1
<i>Weapons: Air-to-Air</i>			
Guided Nuclear	1.9	0	5.1
Guided Conventional	0	0	0
Unguided	3.8	0	0
<i>Aircraft Paramaters</i>			
Altitude	0	0	0
Heading	0	0	0
Airspeed	0	0	0
<i>Ships</i>			
Aircraft Carrier	15.1	27.3	25.6
Tanker	15.1	18.2	10.3
Destroyer	15.1	27.3	25.6
Missile Ship	11.3	13.6	15.4
Submarine	22.6	40.9	12.8

**DISTRIBUTION OF GROUP II (ALPHA-NUMERIC)
CODERS BY SAMPLE PROPORTIONS**

Object, Event	Students	F-15 Pilots	F-111D Pilots
<i>Aircraft</i>			
Fighter	20.8	31.8	30.8
Bomber	26.4	40.9	38.5
Helicopter	24.5	31.8	33.3
Transport	24.5	54.15	33.3
Forward Observer	24.5	36.4	38.5
Reconnaissance	39.6	50.0	61.5
Electronic Jammer	30.2	54.5	48.7
Tanker	30.2	45.5	51.3
<i>Weapons: Air-to-Ground</i>			
Guided Nuclear	34.0	50.0	51.3
Guided Conventional	24.5	54.5	53.8
Freefall Nuclear	30.2	63.6	48.7
Freefall Conventional	30.2	68.2	46.2
<i>Weapons: Air-to-Air</i>			
Guided Nuclear	28.3	59.1	46.2
Guided Conventional	24.5	59.1	51.3
Unguided	26.4	59.1	41.0
<i>Aircraft Parameters</i>			
Altitude	62.3	95.5	92.3
Heading	58.5	59.1	61.5
Airspeed	60.4	95.5	94.9
<i>Ships</i>			
Aircraft Carrier	24.5	27.3	43.6
Tanker	32.1	40.9	56.4
Destroyer	32.1	45.5	43.6
Missile Ship	35.8	45.5	43.6
Submarine	24.5	36.4	48.7

**DISTRIBUTION OF GROUP III (SIMPLE LINES, ETC.)
CODERS BY SAMPLE PROPORTIONS**

Object, Event	Students	F-15 Pilots	F-111D Pilots
<i>Aircraft</i>			
Fighter	28.3	18.2	17.9
Bomber	32.1	31.8	38.5
Helicopter	28.3	18.2	15.4
Transport	45.3	22.7	43.6
Forward Observer	32.1	13.6	33.3
Reconnaissance	35.8	18.2	5.1
Electronic Jammer	39.6	36.4	12.8
Tanker	20.8	22.7	15.4
<i>Weapons: Air-to-Ground</i>			
Guided Nuclear	32.1	22.7	10.3
Guided Conventional	52.8	31.8	17.9
Freefall Nuclear	41.5	13.6	25.6
Freefall Conventional	45.3	13.6	25.6
<i>Weapons: Air-to-Air</i>			
Guided Nuclear	35.8	18.2	25.6
Guided Conventional	47.2	27.5	17.9
Unguided	43.4	22.7	38.5
<i>Aircraft Parameters</i>			
Altitude	26.4	4.5	2.6
Heading	24.5	40.9	38.5
Airspeed	17.0	4.5	2.6
<i>Ships</i>			
Aircraft Carrier	26.4	31.8	20.5
Tanker	28.3	18.2	7.7
Destroyer	45.3	13.6	25.6
Missile Ship	37.7	31.8	28.2
Submarine	35.8	13.6	23.1

**DISTRIBUTION OF GROUP IV (GEOMETRIC SHAPES)
CODERS BY SAMPLE PROPORTIONS**

Object, Event	Students	F-15 Pilots	F-111D Pilots
<i>Aircraft</i>			
Fighter	22.6	9.1	20.5
Bomber	30.2	4.9	10.3
Helicopter	24.5	13.6	7.7
Transport	22.6	18.2	5.1
Forward Observer	26.4	9.1	10.3
Reconnaissance	13.2	9.1	23.1
Electronic Jammer	15.4	9	5.1
Tanker	30.2	4.5	5.1
<i>Weapons: Air-to-Ground</i>			
Guided Nuclear	34.0	9.1	17.9
Guided Conventional	24.5	4.5	7.7
Freefall Nuclear	13.2	4.5	5.1
Freefall Conventional	11.3	9.1	2.6
<i>Weapons: Air-to-Air</i>			
Guided Nuclear	20.8	13.6	7.7
Guided Conventional	22.6	4.5	10.3
Unguided	13.2	9.1	5.1
<i>Aircraft Parameters</i>			
Altitude	7.5	0	2.6
Heading	5.7	0	0
Airspeed	9.4	0	0
<i>Ships</i>			
Aircraft Carrier	22.6	4.5	5.1
Tanker	24.5	4.5	15.4
Destroyer	7.5	4.5	0
Missile Ship	13.2	4.5	2.6
Submarine	9.4	9.1	10.3

DISTRIBUTION OF UNCLASSIFIED CODERS BY SAMPLE PROPORTIONS

Object, Event	Students	F-15 Pilots	F-111D Pilots
<i>Aircraft</i>			
Fighter	26.4	13.8	17.9
Bomber	7.5	9.1	2.6
Helicopter	17.0	9.1	7.7
Transport	1.9	0	7.7
Forward Observer	13.2	9.1	5.1
Reconnaissance	9.4	4.5	5.1
Electronic Jammer	9.4	4.5	7.7
Tanker	3.8	4.5	7.7
<i>Weapons: Air-to-Ground</i>			
Guided Nuclear	3.8	18.2	15.4
Guided Conventional	5.7	9.1	15.4
Freefall Nuclear	13.2	18.2	17.9
Freefall Conventional	9.4	9.1	20.5
<i>Weapons: Air-to-Air</i>			
Guided Nuclear	13.2	9.1	15.4
Guided Conventional	5.7	9.1	20.5
Unguided	13.2	9.1	15.4
<i>Aircraft Parameters</i>			
Altitude	3.8	0	2.6
Heading	11.3	0	0
Airspeed	11.3	0	2.6
<i>Ships</i>			
Aircraft Carrier	11.3	9.1	5.1
Tanker	0	18.2	10.3
Destroyer	0	9.1	5.1
Missile Ship	1.9	0	10.3
Submarine	7.5	0	5.1

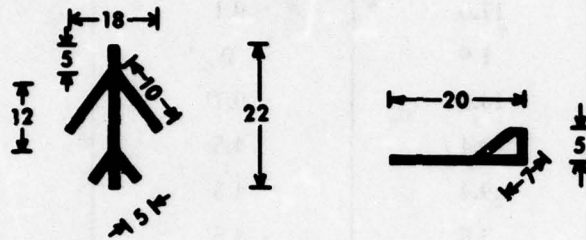
APPENDIX 7

COMMON DESIGNS FOR TACTICAL SYMBOLS ORIGINATED BY SUBJECTS

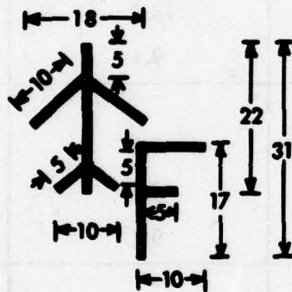
I AIRCRAFT

AIRCRAFT - IN GENERAL

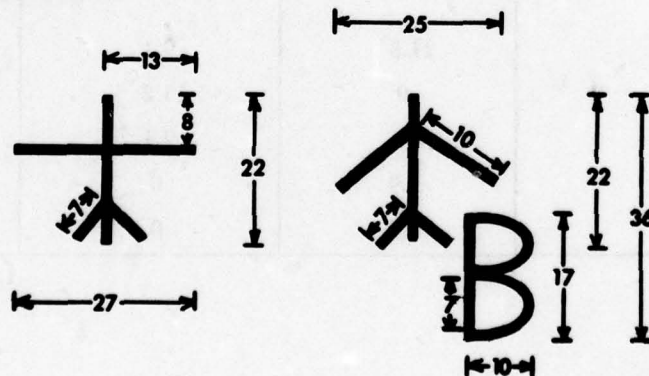
NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology standardization Committee.



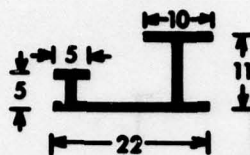
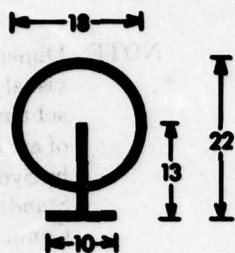
FIGHTER



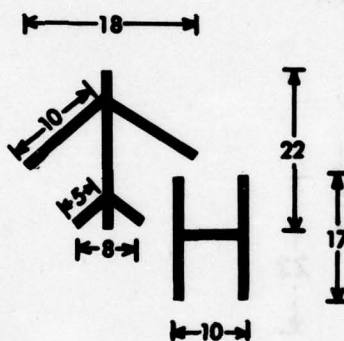
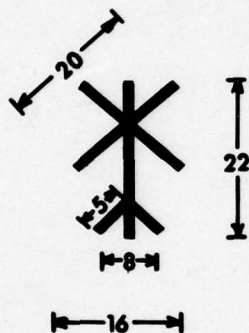
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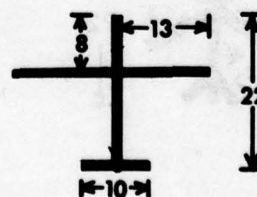
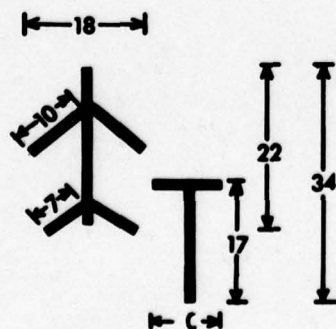
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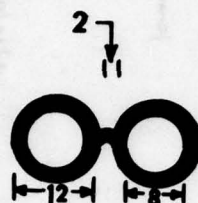
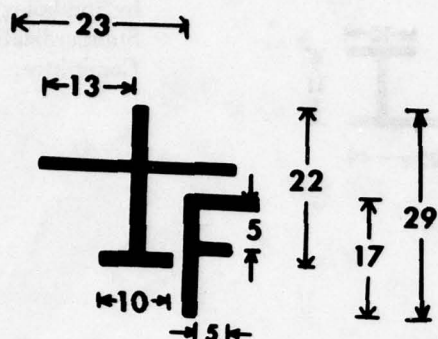
NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.



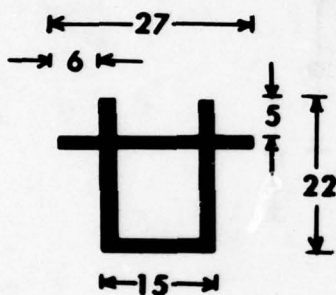
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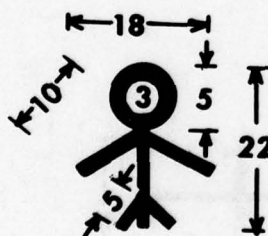
FOWARD OBSERVER



NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

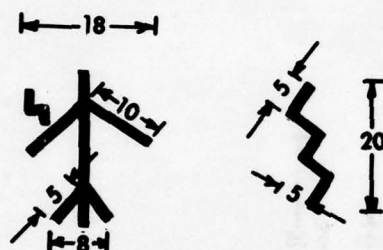
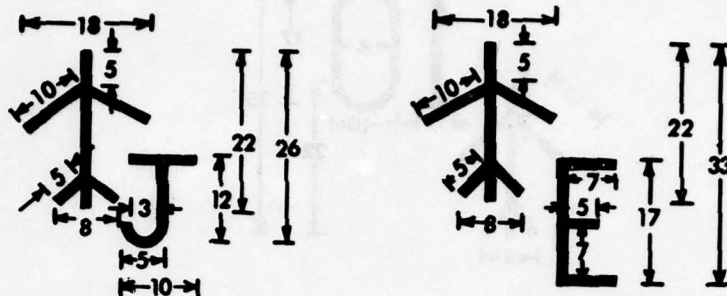


RECONNAISSANCE

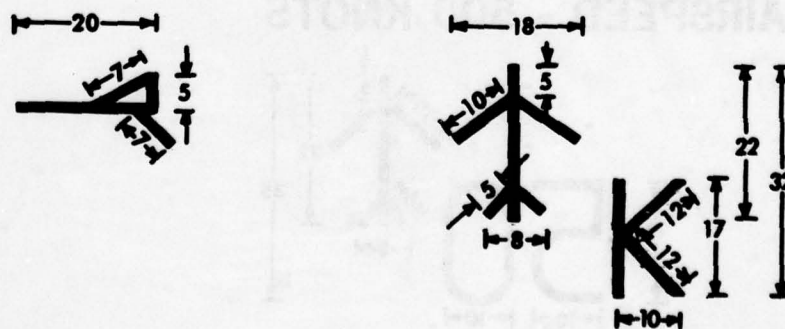


ELECTRONIC JAMMER

NOTE: Dimensions are
visual angle
subtended in minutes
as suggested
by Symbology
Standardization
Committee.



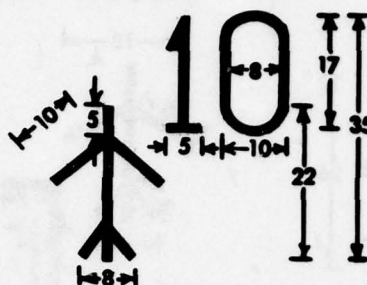
TANKER



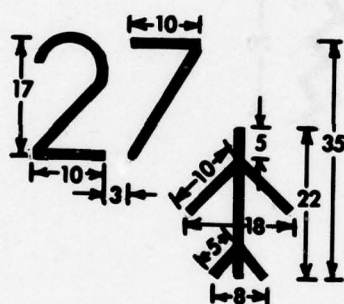
IV AIRCRAFT PARAMETERS

NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

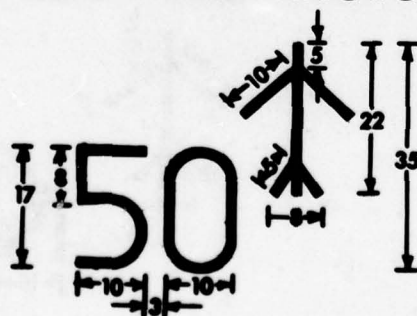
ALTITUDE - 10,000 ft



HEADING - 270°



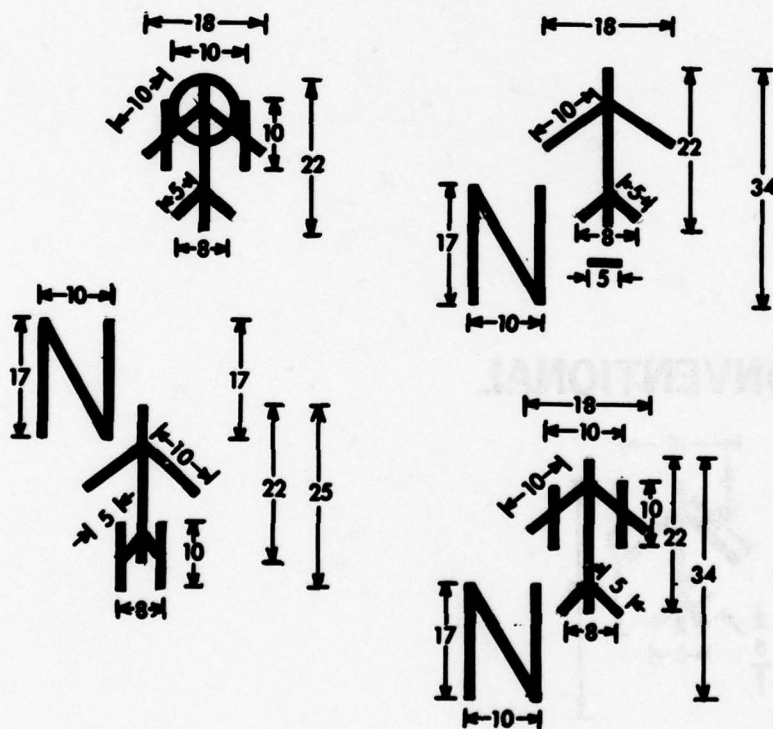
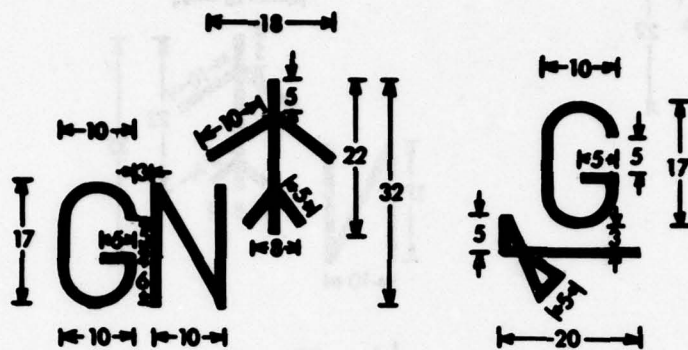
AIRSPEED - 500 KNOTS



II WEAPONS - AIR TO GROUND

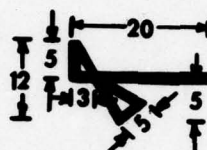
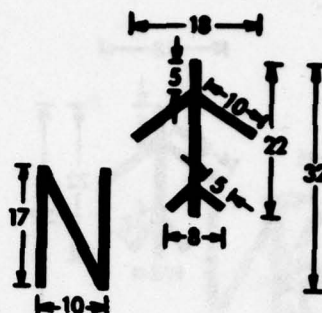
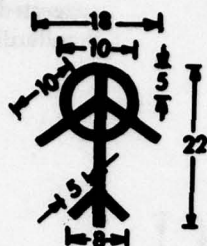
GUIDED NUCLEAR

NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

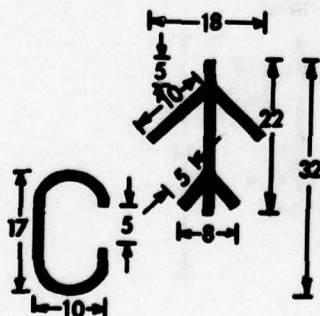


FREEFALL NUCLEAR

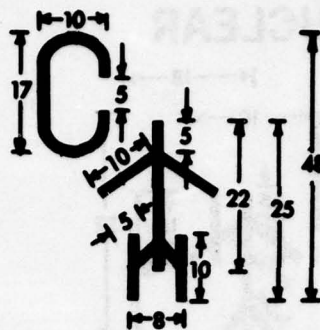
NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.



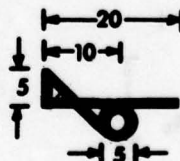
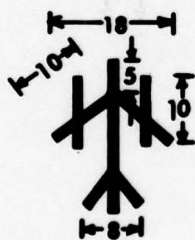
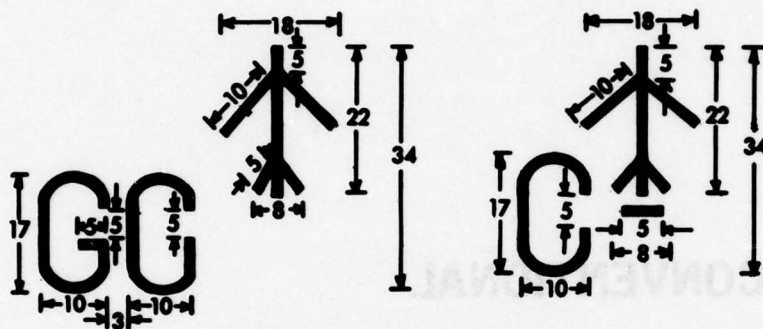
FREEFALL CONVENTIONAL



GUIDED CONVENTIONAL

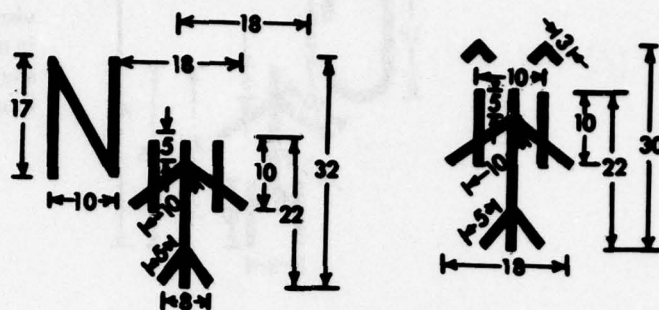


NOTE; Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.



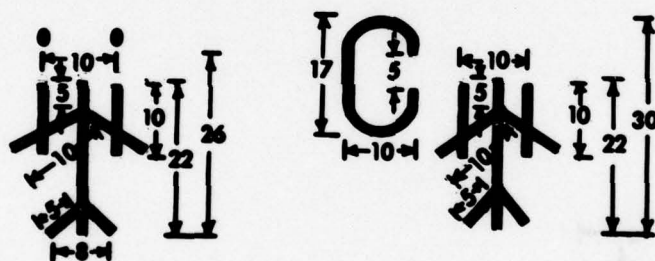
III WEAPONS - AIR TO AIR

GUIDED NUCLEAR

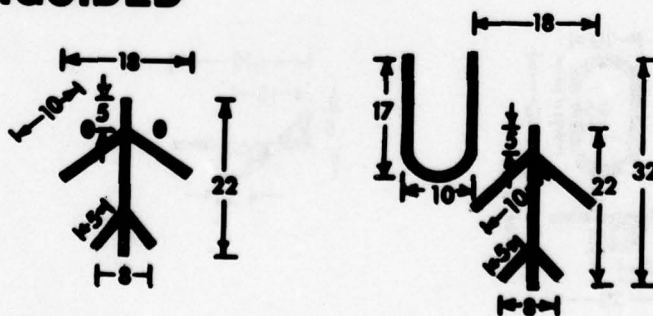


NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

GUIDED CONVENTIONAL



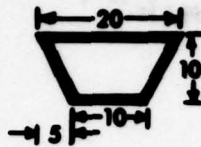
UNGUIDED



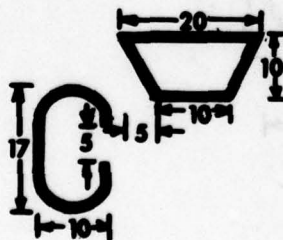
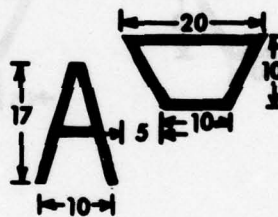
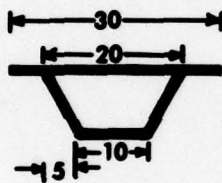
V SHIPS

NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

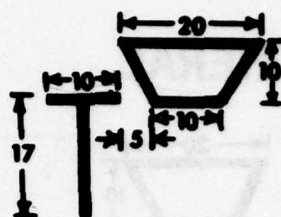
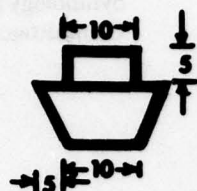
SHIP - IN GENERAL



AIRCRAFT CARRIER

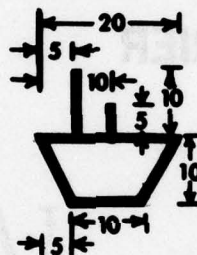
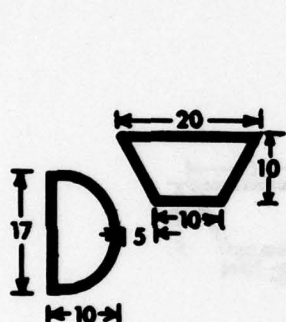


TANKER

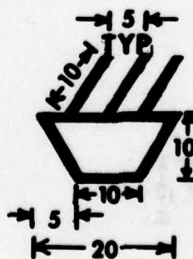
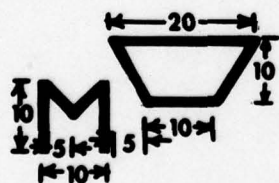


NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

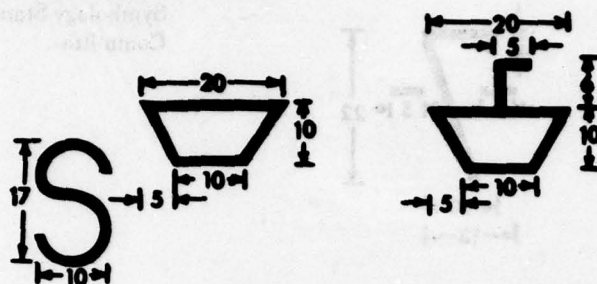
DESTROYER - BATTLESHIP



MISSILE SHIP



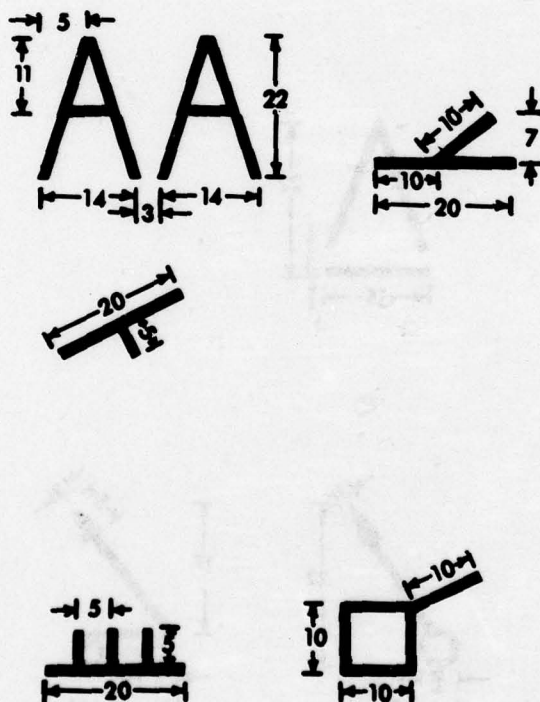
SUBMARINE



NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

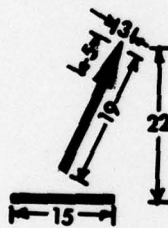
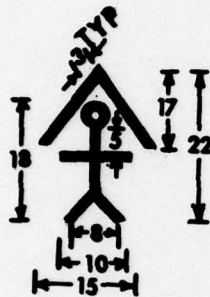
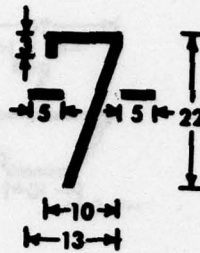
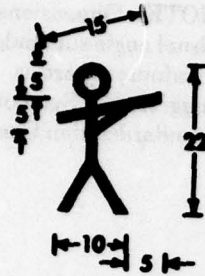
VI GROUND TARGETS

AAA

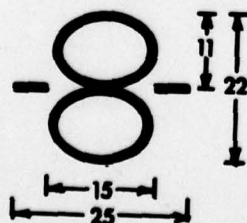
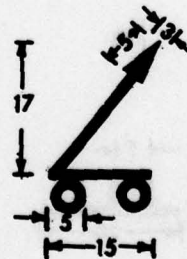
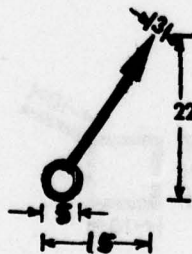


HAND-HELD SAMS

NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

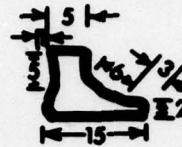
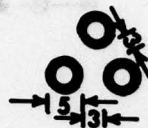


MOBILE SAMS

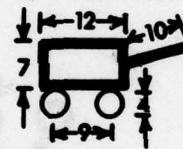
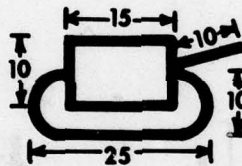
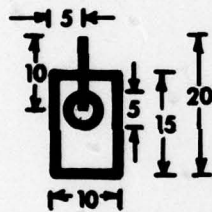


TROOPS

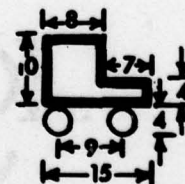
NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.



TANKS

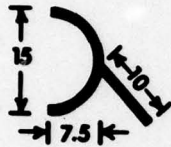
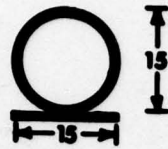


CONVOY

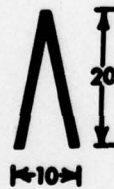
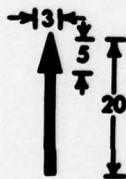
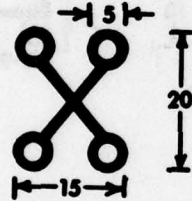


RADAR INSTALLATION

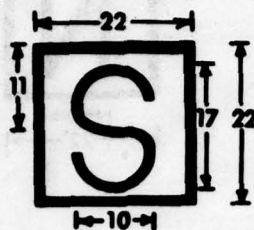
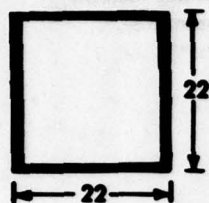
NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.



SAM SITE

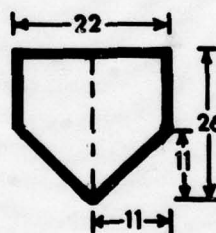


SAFE AREA

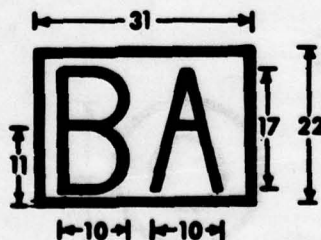


NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

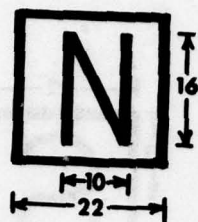
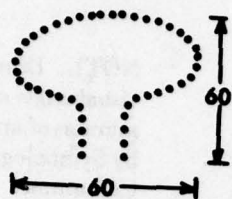
BASE OF ORIGIN



BOMBING AREA

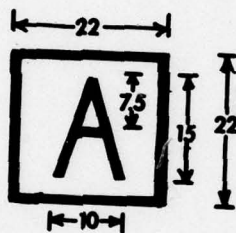


NUCLEAR BLAST

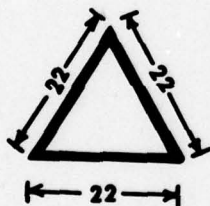


NOTE: Dimensions are visual angle subtended in minutes of arc as suggested by Symbology Standardization Committee.

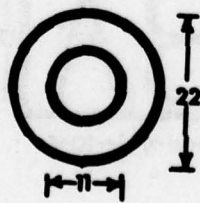
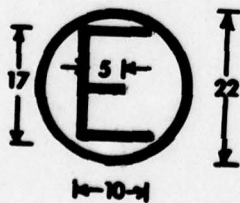
DOWNED AIRCREW



TARGET












































































EMERGENCY BASE




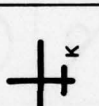

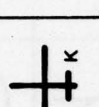

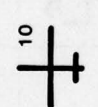
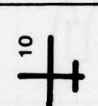
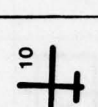




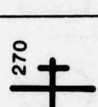

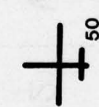
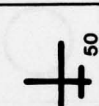
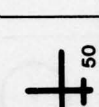
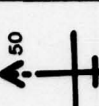

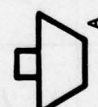




























































APPENDIX 8

MOST FREQUENT DESIGNS FOR TACTICAL SYMBOLS


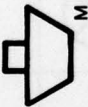




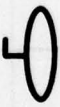

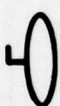









OBJECT	S.S.C.	STUDENTS		F-111 PILOTS		F-15 PILOTS		POSSIBLE ALTERNATIVES	
		1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE		
FRIENDLY			F	F			F		0
ENEMY			E	E			E		X
UNKNOWN			U	U			U	0	?
AIRCRAFT*			↑		↑				
TARGET			T		TGT		TGT		
INITIAL POINT		IP			IP		IP		

OBJECT	S.S.C.	STUDENTS		F-111 PILOTS		F-15 PILOTS		POSSIBLE ALTERNATIVES	
		1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE		
FIGHTER									
BOMBER									
HELICOPTER									
TRANSPORT									
FORWARD OBSERVER									
RECONNAISSANCE									
ELECTRONIC JAMMER									

OBJECT	S.S.C.	STUDENTS		F-111 PILOTS		F-15 PILOTS		POSSIBLE ALTERNATIVES
TANKER								
ALTITUDE (10KA)								
HEADING (270°)								
AIRSPEED (500kts)								
AIRCRAFT CARRIER								
TANKER								
DESTROYER								

OBJECT	S.S.C.	STUDENTS		F-111 PILOTS		F-15 PILOTS		POSSIBLE ALTERNATIVES
		1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	
SHIPS								
RADAR INSTALLATION								
WAYPOINT	W2	WP	/				W	
NUCLEAR BLAST			NB					
TANKS			X				TK	
AAA	A		A				A	
EMERGENCY BASE		E					E	

OBJECT	S.S.C.	STUDENTS		F-111 PILOTS		F-15 PILOTS		POSSIBLE ALTERNATIVES
		1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	
DOWNED AIRCREW			DA		DA		DA	SAR
SAFE AREA			S					
GROUND TROOPS			GT		GT		XXX	
BASE OF ORIGIN			BO					
SAM SITE	S		SS		S		S	
BOMBING AREA			BA		BA		BA	
CONVOY		C			C			

OBJECT	S.S.C.	STUDENTS		F-111 PILOTS		F-15 PILOTS		POSSIBLE ALTERNATIVES	
		1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE	1st CHOICE	2nd CHOICE		
MISSILE SHIP									
SUBMARINE									
MOBILE SAMS	-8-			-8-		-8-			
HAND-HELD SAMS	-7-			-7-		-7-			

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